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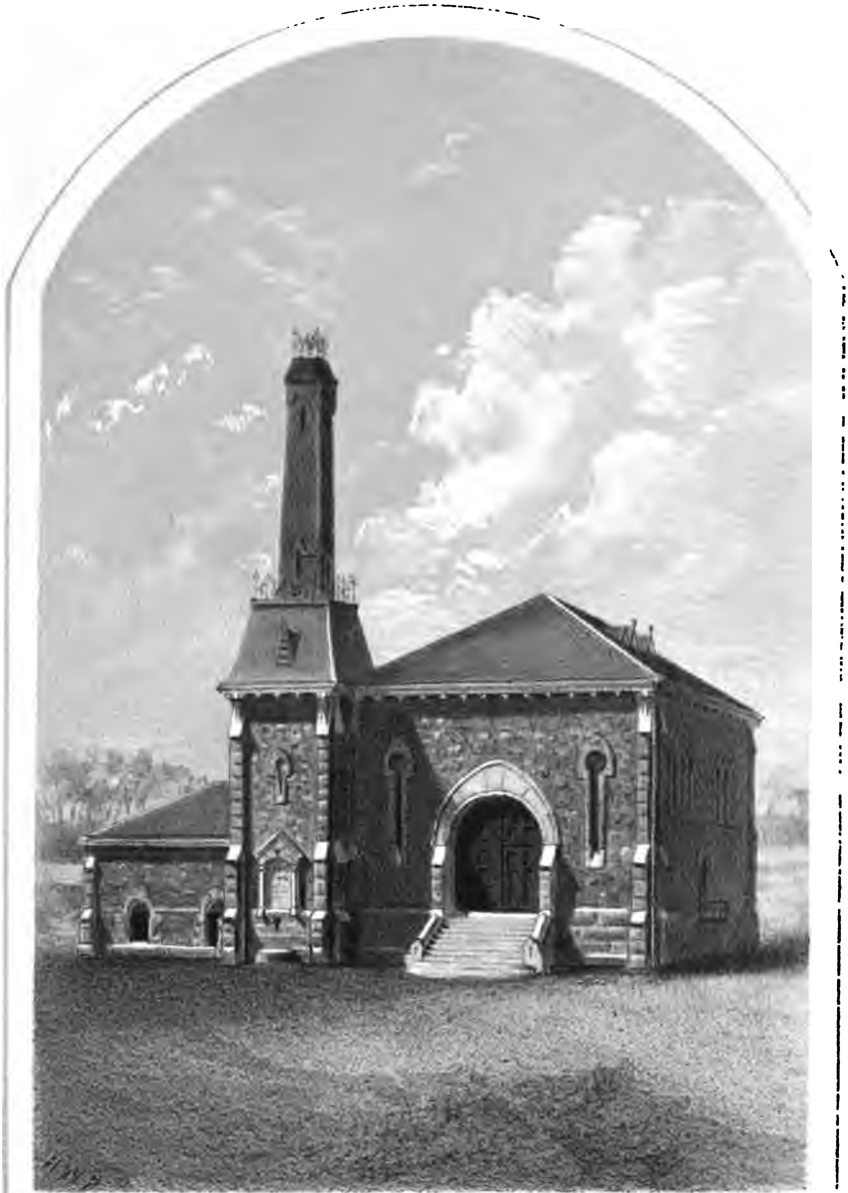

New Eng. Lith. Co. 289 Summer St Boston

ENGINE HOUSE.

1871.—CITY DOCUMENT No. 10.

NEW BEDFORD WATER WORKS.

REPORT

OF THE

ACUSHNET WATER BOARD,

TO THE

CITY COUNCIL,

CONTAINING:

1. *The Operations of the Board for the Year* 1870.
2. *A History of the Works to the Close of the same Year.*
3. *The Report of the Engineer and Superintendent to the Board, giving a Description of the Works.*
4. *A Description of the Pumping Engine, and a Statement of its Working, by a Board of Examiners.*

PRINTED BY ORDER OF THE CITY COUNCIL.

NEW BEDFORD:
FESSENDEN & BAKER, CITY PRINTERS.
1871.

Eng 1070.602
Mass. Doc 24.15.55

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1918

NEW BEDFORD WATER WORKS.

ACUSHNET WATER BOARD.

EX-OFFICIO MEMBERS.

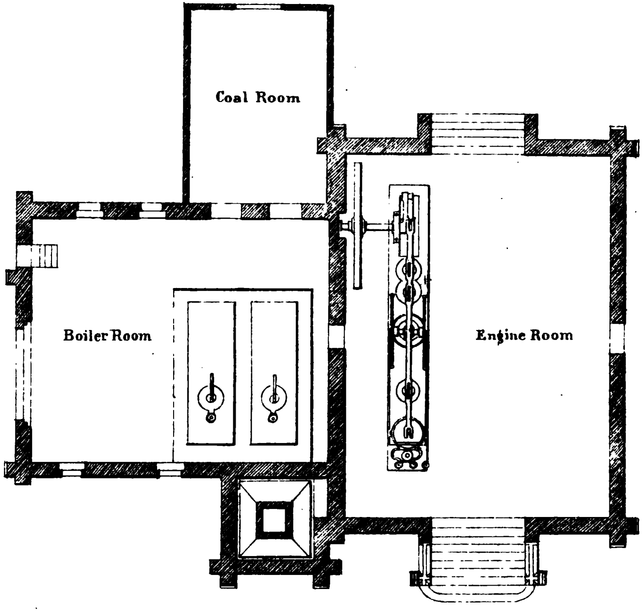
His Honor GEORGE B. RICHMOND, Mayor, President of the Board.
CHARLES M. PEIRCE, Jr., Esq., President of the Common Council.

MEMBERS AT LARGE.

WILLIAM W. CRAPO, Esq., (term expires June, 1873.)
WARREN LADD, Esq., (term expires June, 1872.)
DAVID B. KEMPTON, Esq., (term expires June, 1871.)

Clerk of the Board—JAMES B. CONGDON.
Engineer — GEORGE A. BRIGGS.
Assistant — ISRAEL C. CORNISH.
Superintendent — GEORGE A. BRIGGS.
Pumping-Engineer — CHARLES B. SMITH.
Water Registrar — JAMES B. CONGDON.

No. 1.



GROUND PLAN
OF
ENGINE HOUSE

New Eng. Lith. Co 109 Summer St Boston.

REPORT.

City of New Bedford,
Office of the Acushnet Water Board,
December, 1870.

To the City Council of the City of New Bedford:

Gentlemen,—By the 18th Section of the "Ordinance to provide for the establishment of the Acushnet Water Board, and for the care and management of the New Bedford Water Works," passed October 29th, 1869, it is provided that "the Acushnet Water Board shall on some day during the month of December, annually place in the hands of the Mayor, a Report to the City Council; which Report shall contain, in addition to the Report to the Board from the Superintendent, a full statement of the operations of the Board up to the last day of the month of November; a detailed account of the receipts and expenditures, up to and including the audit of said month of November; a statement setting forth the cost of each branch of the Works up to that time; and a schedule of the lands and other property belonging to the City, and connected with the Works. And it shall be the duty of the Board in their Annual Report, to lay before the City Council all such information, and to make all such suggestions as may be deemed needful in connection with the condition and operation of the Works."

The office of the Water Commissioners, created by the Act of the General Court, passed April 18th, 1863, expired on the 30th day of November, 1869. The charge of the enterprise then devolved upon the Acushnet Water Board, and in accordance with the provisions of the Ordinance above cited, that Board now presents to the City Council its first Annual Report.

The Water Commissioners had, up to the period when the office ceased to exist, presented to the Joint Special Committee of the City Council on Water, monthly Reports of the progress of the Works. These Reports thus frequent, and embracing all the important proceedings of the Commissioners, gave to the City Council the information needed by that body in relation to their operations; and, at the close of their labors, the files of the Council contained, in these monthly Reports, a full history of the undertaking.

It was, however, the intention of the Water Commisioners, at the expiration of their term of office, to have prepared a Report to the City Council which would have embraced in its statements the whole period during which the Works were under their charge. All these gentlemen are members of this Board; and on their behalf the statement is made, that after giving the subject due consideration, they came to the conclusion, that the time had not then arrived for such a general statement in relation to the New Bedford Water Works, as it was desirable should be made upon their completion.

In their final Report, dated November 30th, 1869, the Commissioners say:—"The near completion of the Water Works, together with the fact that the powers and authority, which, by the provisions of the Act of the Legislature and the Ordinances of the City, they have exercised for the last four years, now terminate, render appropriate a full and detailed Report of their doings. But the Commissioners find it impracticable at the present time to make such a Report as the full completion of the work will require, and content themselves with the single statement of its condition and the exhibit of their expenditures to date; reserving to a future communication, a more extended and minute account of the history and progress of the great public interest entrusted to their charge. A supplement to this Report, after the completion of the Water Works, will, in their judgment, prove more satisfactory than the imperfect statements only, which can now be made; and such supplementary Report it is proposed to submit as soon as the same can be properly prepared."

The time having arrived when the "extended and minute account of the history and progress of this great public interest" contemplated by the Commissioners can be prepared, it is proposed, instead of the "supplement" proposed by them, to include in this Report all that would have been included in the general history and detail of expenditure which they had in view, as well as a statement of the operations of the year, during which the present Board have had the management and responsibility of the enterprise.

It is believed that this course will be much more satisfactory to the Council and to the citizens, than one which would have separated the Report of the Commissioners from that of the Water Board, and left them both to some extent imperfect, or rendered necessary an extended and useless repetition in this of the contents of the other.

This Report, then, while it meets the requisitions of the Ordinance creating this Board, and will give in detail under the respective heads the expenditures of the year that the Works have been in our charge, will also embrace, in point of time, the whole period included in the enterprise, and give such an "account of the history and progress of this great public interest" as its magnitude and importance demands. It is proposod to give in this Report, in connection with the description of the Works to be included in the Report of the Local Engineer and Superintendent, and the Report upon the pumping engine, prepared with great care by the Commission of Engineers assembled in this City from different parts of the country for the special purpose of its examination, a description that will contain all that it may be desirable for the Council, the citizens, the engineers and mechanics to know of this important undertaking. It is now so far completed that a full Report at this time will include the facts necessary to a full understanding of its character and cost.

HISTORY.

In the brief history which we propose to give of the New Bedford Water Works, we shall confine ourselves mainly to the proceedings of the City Council, and the operations of the Water Commissioners and of the Water Board.

The first movement in relation to the Introduction of Water into the City was made more than ten years ago. On the 8th day of March, 1860, the following order was introduced into the Common Council by Frederick S. Allen, Esq., and passed both branches of the City Government.

> "IN COMMON COUNCIL,
> March 8th, 1860.
>
> *Ordered*, That a Joint Special Committee, consisting of four persons from this Board, with such as the Mayor and Aldermen may add, be appointed to consider the practicability and expediency of introducing a permanent supply of fresh water into the City, and report some plan, with the probable cost of doing so, and that said Committee be allowed six months to report thereon." *

In July of that year the Committee made a Report, in which they stated that they had visited several localities, but were unable, in the absence of any surveys, to make any estimate of the cost. By their request an order was passed, July 26th, 1860, authorizing an expenditure of *three hundred dollars* "for the purpose of testing the practicability of introducing a permanent supply of fresh water."

On the 21st of the following December the Committee made their report.

They state in their Report that "the examination has been continued by Messrs. William F. Durfee and George A. Briggs, under the direction of Capt. Charles H. Bigelow, and that the results are given in the report of Capt. Bigelow." Upon the recommendation of the Committee the further consideration of the subject was referred to the next City Government.

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* The Committee consisted of Messrs. Hunt, Lewis and Reynard on the part of the Mayor and Aldermen, and Messrs. Allen, E. Perry, Anthony and Hammett.

In his address to the City Council, January 7th, 1861, Isaac C. Taber, Mayor of the City, makes the following remarks on the subject of the introduction of water.

> "In March last an order was adopted, directing an inquiry to be made into the expediency and practicability of introducing into the City an ample supply of fresh water, together with the probable cost of such Works as would meet the requirements of the community. From various causes, the Report was delayed to so late a day as to preclude any present action, and the subject was deferred to the next City Government.
>
> I should not deem it in place here to set forth the many strong arguments which might be adduced in favor of a liberal outlay in this direction; but involving as it does, so much of importance in the sanitary, economical and business interests of the City, I should be unwilling to leave the subject without urging it strongly upon your attention, with the hope that at an early day the subject may be resumed and carried through to a successful consummation."

In accordance with this recommendation, another Joint Special Committee was appointed on the 17th day of the same month.*

The Report of this Committee is dated December 21st, 1861, and on the 4th day of January following, the City Council ordered it to be printed. In addition to the main Report, which is signed by Isaac C. Taber, as Chairman, it contains the Reports made to the Committee by Capt. Charles H. Bigelow, Engineer, and George A. Briggs, Esq., City Surveyor. Capt. Bigelow's Report is dated December 12th, 1861, and that of Mr. Briggs, September 17th.

We have space for abstracts only of these able documents.

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*The Committee was composed of the Mayor, Aldermen Lewis and Reynard, and Common Councilmen, Howland, Allen, Perry and Taber.

The Report proper states that the surveys and measurements of Capt. Bigelow and Mr Briggs settle the question of practicability.

It gives the preference to the Acushnet River as a source of supply, and proves conclusively that from this source a supply can be obtained, for double the present population of our City, allowing for an average *daily* consumption of two *barrels for each person*—man, woman and child. It is further shown, that at a small expense, other sources of supply are accessible.

The question of outlay is fully considered, and the expense is estimated at about half a million of dollars.

In the view of the Committee, the introduction of water is a "mechanical necessity."

The Report gives prominence to the consideration, that the business of the City demands this indispensable auxiliary.

> "Looking at it," says the Report, "simply as a mechanical auxiliary, your Committee are fully of opinion that the introduction of an ample supply of pure water into the City is an imperative necessity, and one which should not much longer be delayed. There never was a time when the work could be done at less expense, or when labor and capital stood more in need of employment. It is a part of wise statesmanship to look at the future, to anticipate its wants and guard against its casualties.
>
> Cities, like men, flourish and prosper only by their own exertions; and it becomes those, whom the people have placed in power and trust, to be equal to the present emergency. We have the honor and interest of the City in our hands. We know its wants and necessities, and can comprehend the present crisis in our affairs. Shall we grasp and control that crisis, turn it with a steady hand to our interests and prosperity? or allow it silently and timidly to pass by and float beyond our reach? Shall we legislate only for to-day, and shrink from looking the great future in the face? or shall we, knowing the necessity and perceiving the remedy, fearlessly perform our duty."

In his Report to the Committee, Capt. Bigelow clearly shows that the Acushnet River is the only reliable source of supply, and that this supply is ample. He proceeds to state that the water must be brought into the City through a brick conduit,—that it will require to be pumped into a reservoir upon the heights, and from thence be distributed through the City by means of pipes.

His estimates are those upon which the Committee based the statement of the cost of the operation. Capt. Bigelow closes his Report, which he calls "preliminary and provisional," as follows:

"I cannot close this preliminary and provisional Report, without seizing the opportunity to allude to the great advantages which would accrue to the City by obtaining an ample supply of pure water.

First,—Its *sanitary* condition could not fail to be greatly benefited in cleaning its sewers and vaults, and providing a wholesome beverage in many places where only an impure one can now be obtained; and this, while ministering to the cleanliness of the people, and, as all experience shows as a necessary result, a most effective instrument of advancing their morals.

Second,—The comfort and welfare of the inhabitants would be vastly promoted, *privately,* by providing a constant supply of this necessary element within their houses, obtained without labor and at a trifling annual charge, which would doubtless be found, in the long run, to be far less than the expense of the present clumsy and laborious contrivances for raising it from wells.

The *public* welfare would be promoted by open hydrants and fountains, ornamenting and cleansing the streets, allaying the dust, &c., &c.

Third,—The *shipping* could be easily and abundantly supplied.

Fourth,—The security of property would be greatly increased, and the cost of insurance lessened, by providing a constant, self-acting prevention against fires and conflagrations.

Fifth,—The greatest and most important advantage of all would consist in obtaining an ample supply for mechanical uses in all parts of the City.

Hardly a city in Massachusetts, or any where else, is so poorly provided for in this respect as New Bedford. In the whole southern part of our City, sufficient water cannot be obtained in one locality for supplying a steam engine of any considerable size, and in the northern part, the natural supply may now be considered as well nigh exhausted.

This difficulty meets any enterprise requiring steam power for its accomplishment upon the threshold; and in part has been and will be an insurmountable one, except by means of a public aqueduct.

Of course this consideration virtually effects the interest of this place in its mechanical and manufacturing prospects; and all attempts must fail to substitute such occupations and interests for the single one, which has so long and so prosperously engaged the attention of the people here, but which has now so ominously diminished, unless with a strong and unflinching public spirit, the City will first provide the essential pre-requisite of an abundant, omnipresent supply of pure water."*

The Report of the City Surveyor is mainly devoted to the subject of the supply of water. This is proved to be ample. The details of sundry observations are given, and it is conclusively shown that a daily supply from the Acushnet of *two millions eight hundred and six thousand and thirty-nine gallons* could be relied upon. This would give sixty gallons each to *forty-seven thousand six hundred and seventy-three* inhabitants.

The Report of a sub-Committee of the Joint Special Committee accompanied the Report. It takes the estimates of Capt. Bigelow as a basis of calculation, and goes somewhat into detail as to the cost of the distribution of the water.

These estimates are now of but little interest or value. Circumstances were so greatly changed before they could be brought to the test of actual working, that they possessed but little utility when the City was prepared to engage in the operation. It was supposed by them that it would require *seventeen and a half* miles of pipe to meet the wants of the inhabitants.

In his address of January 6th, 1862, Mayor Taber again introduces the subject to the attention of the Council. The Reports, abstracts of which we have introduced above, had been made, and the subject had now assumed an aspect that gave confidence in the movement.

"The subject," says Mayor Taber, "of the introduction of an ample supply of fresh water has for two years past engaged the attention of the City Council; and from the several Committees, to whom the subject has been referred, has received the attention which its importance demands.

The Committee of last year, though nearly unanimous in favor of some immediate action in the matter, did not deem it expedient to urge it at the present time.

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*Capt. Charles H. Bigelow was an engineer in the service of the United States, and when he performed this work for the City, he had charge of the construction of the Fort upon Clark's Point. He died here soon after the date of his Report. His widow is a daughter of the late Gov. Briggs. He was greatly esteemed by all who knew him.

"The able Reports of Capt. Charles H. Bigelow, and of Mr. George A. Briggs, the City Surveyor, show its entire practicability, and the possibility of procuring and bringing into the City, at a comparatively small expense, all that the City will probably require for many years to come.

Should the project at some future time be carried into effect, it will undoubtedly call for an apparently large expenditure; but in the details, which will be shortly laid before you, it will be shown that the future prosperity of the City will be mainly dependent upon the execution of the work, and that the money so expended would be returned to us many fold, in the encouragement of individual enterprise, the increased employment of labor, and the advanced value of real estate; to say nothing of the general sanitary and economical effects of an abundant supply of good water.

The Committee of the last City Government, to whom the whole matter was referred, would have urged earlier action in the matter, but in the present distracted condition of our country, and the constantly repeated calls upon our City for relief, and the comparatively large outlay by the City for the encouragement of enlistments and the defense of our harbor, induced them to delay the recommendation of an undertaking, the importance of which they fully understood and appreciated."

Notwithstanding the argument and recommendation for delay, intimated in the Report and fully expressed in the Mayor's address, the subject was immediately brought up in the Council and another Committee appointed. On the 30th day of January, the usual order was passed and the Committee designated.*

On the same day an order passed the Council authorizing the Mayor to petition the General Court for authority to introduce water into the City from the Acushnet River, "or from such source as the Council may deem expedient."

It does not appear that anything was done to further the movement during the year 1862.

On the 5th day of January, 1863, George Howland, Junior,† Mayor of the City, in his inaugural address thus directs attention to the subject:

---

* The Mayor, Aldermen Ladd and Reynard, and Messrs. George Howland, Junior, Edward T. Taber, ——— Brownell, and Charles M. Peirce, Junior.

† Mayor Taber died on the 29th of September, 1862, and George Howland, Junior, was chosen by the City Council to fill the vacancy. At the next election he was chosen to that office for the year 1863.

"The subject of supplying the City with fresh water has been agitated to some extent, both in and out of the City Council, for the past two or three years.

A Report of the Committee having the matter in charge, was made to the Council of the year 1861, giving a somewhat detailed statement of the possible supply of water within our reach, and also some estimates of the probable cost of the undertaking. The subject has been allowed to remain quiet so far as any action of the City Government has been concerned, from that time until a very recent period, when a petition to the Legislature was published, in accordance with a requisition of law, giving notice that application might be made to that body at its next session, for authority to introduce pure soft water into the City, with the necessary adjuncts.

There the matter rests; and it will devolve upon you, gentlemen, to determine whether the proposed authority shall be asked or not, whether the matter shall go on, or remain, as now, at rest.

There are among our citizens, many who place a high value upon the measure, while others do not regard it in so important a light.

For my own part, on the basis as laid down by the Report alluded to, I am free to say, that I do not think the time has fully arrived for such an outlay, upon an issue about which there is so much doubt.

Were we not already supplied, so far as sanitary or culinary purposes are concerned, with as good and as pure water as any community can require, the subject would present itself to my mind in a very different aspect.

Who among us, for his own personal or domestic use, would, if water were distributed through our streets, introduce it into his private premises? probaprobably very few if any; the only purposes for which we want it then, as it seems to me, is for manufactories and the extinguishment of fires.

This brings us to the question, will the introduction of fresh water for the purpose of manufacturing, induce our capitalists to embark in a new, and until experience is gained, an unknown business? or are we to look for capital from abroad to come in and establish new branches of industry among us?

What assurance have we that either of these results will be attained, if the plan contemplated, and perhaps necessary to such enterprise, is consummated?

In short, gentlemen, are we prepared to go forward in the movement, from what data we have in our possession? If we are, let us proceed; if not, let us investigate; and, if upon investigation, any other or better course suggests itself for our consideration, let us give the matter that careful consideration which its importance demands.

I will venture to propose, that should the Council determine to go forward and obtain the legislative authority before attended to, the grant should contain a proviso that the whole subject shall be referred to the voters of our City for their acceptance or otherwise."

This somewhat discouraging view of the subject on the part of Mayor Howland, did not dampen the ardor of those who had most zealously interested themselves in the subject.

On the 15th of the month, an order was adopted by the Board of Aldermen and concurred in by the Common Council, providing for the appointment of another joint Committee to make surveys and estimates, to enquire into the "feasibility and cost" of the operation; and to obtain from the General Court the necessary authority. An appropriation of three hundred dollars was placed at the disposal of the Committee.*

The Committee promptly and vigorously commenced the work assigned them. Their Report bears date December 29th, 1863.

The professional abilities of Professor George I. Chase, and of Mr. George A. Briggs, the City Surveyor, were engaged in the enquiry which was instituted by the Committee.

Professor Chase's Report, which is dated November 20th, 1863, contains clear and exhaustive statements upon the several points to which his attention was directed.

He examines the valley of the Acushnet and finds it "admirably fitted for gathering and storing supplies of water."

He makes an analysis of the water of the Acushnet and declares it to be of "remarkable purity."

In conclusion he says: " If the storing and distributing reservoirs be properly prepared, I am inclined to think that no filtering apparatus or arrangements will be required. The water is gathered from so gentle slopes and borne so short a distance, that few earthy particles find their way into it. Samples of water taken for analysis, are usually passed through a filter to separate the suspended matter. Those from the Acushnet were so clear I did not deem this necessary. The very small amount of impurity given above, includes all the foreign substances contained in the water, whether suspended or dissolved.

Permit me in conclusion, gentlemen, to congratulate you on having at so easy command an ample supply of pure, fresh water. The advantages attending its introduction to your City will be varied and important. It will add not a little to the general health and comfort of the citizens. Entering every house, and, if desired, every part of the house, it will furnish unnumbered domestic conveniences, and reduce materially the amount of service required. It will give a new impulse to your manufacturing interests by affording a needed facility for their extension and growth. In effecting this, its quality will be hardly less influential than its quantity. Water from any of the limited sources now available, would cause in one month a thicker incrustation on the boiler of the steam engine than that from the Acushnet in six months. These incrustations do a double injury. In the first place, by preventing the water from coming into direct contact with the bottom of the boiler, they cause the iron to burn out rapidly. In the second place, from their imperfect conducting power, they obstruct the passage of the heat into the water and thus occasion a loss of fuel. Both of these evils will be substantially avoided by the use of the water of the Acushnet.

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* The Committee were as follows: Aldermen Ladd and Perry, and of the Common Council, Messrs. Taber, Hammond, Chisholm, Kingman and Gifford.

The introduction of this water would also favor the establishment of the more delicate manufacturing operations,—such as bleaching, dyeing and calico printing,—in the conduct of which pure water is an essential requisite. In these various ways I cannot doubt that the important public improvement proposed, if carried out by a corresponding enlightened public spirit, will contribute not a little to the growth of your beautiful City, and that the cost of the undertaking, although necessarily large, will be far more than returned to you in an increased material prosperity.

BROWN UNIVERSITY, Nov. 20th, 1863."

The Act for supplying the City of New Bedford with pure water, which makes a part of the Report, was passed April 18th, 1863. It is in the usual form of such enactments. It provides for the choice of Commissioners; gives power to take land, water and water-rights for the purposes of the Works; for the purpose of defraying the cost, authorizes the issue of "Water Bonds of the City of New Bedford" to an amount not exceeding *five hundred thousand* dollars; provides for the passage of all such by-laws and ordinances as may be deemed necessary; gives authority for the City Council to "organize a department with full powers for the management of the Works and the distribution of the water; and makes it the duty of the Council, "*from time to time, to regulate the price or rent for the use of the water, with a view* *to the payment from the net income and receipts, not only of the semi-annual interest, but ultimately of the principal of the debt so contracted.*"

The Report of the City Surveyor, George A. Briggs, bears date 3d mo. 11th, 1864. It was not included in the Report of the Water Committee when that was presented at the close of the year 1863, but made a part of it when printed.

The Surveyor enters at length into the several important subjects connected with the undertaking. In relation to the supply he says:

> "It is proposed to raise the water in the storing reservoir about *two* feet above the present height of the water in Ansel White's Pond, or to *forty* feet above ordinary high tide at New Bedford. By so doing about *three hundred* acres of land would be flowed to an average depth of about *three and a quarter* feet, making the storage capacity of the reservoir equal to 315,498,000 gallons wine measure; and should the vegetable deposit be removed as proposed, the capacity of the reservoir will be increased to 400,000,000 gallons; a quantity sufficient to last a city of 50,000 inhabitants, *one hundred and thirty-three* days, allowing *sixty* gallons per day to each inhabitant, with no supply running into the reservoir during that time. Now if the minimum supply should be reduced as low as 2,500,000 gallons per day, (which from all the facts I have been able to collect, I hardly think possible,) it would take *seven hundred and ninety-nine days* to reduce the storage to the daily minimum supply."

From a statement, showing the comparative purity of water supplied or proposed for supplying various cities, it was shown that upon a list of *forty-one*, in which is set forth the "solid residue per gallon in grains" in the water, the water of the Acushnet stands *fourth*; having but *one and three-quarters grains* to the gallon. This solid residue ranges from 1.05 to 27.20 grains per gallon. Spot Pond being the minimum, and the Thames water, supplied by the Chelsea Company of London, the maximum.

A large part of the Report of the City Surveyor is devoted to estimates which now are of little interest and of but little practical value. They are based upon the proposition to bring the water into the City by gravity only, leaving out any calculation for pumping, and distribution throughout the City.

With regard to this subject the Surveyor says:

> "In most of the cities where water is artificially supplied it is done by pumping. Cities supplied by gravitation are the exception. The relative merits would be determined by the shorter line more than compensating for the extra expense of pumping. It would be desirable to have a supply of water near the City and at an elevation so high that it could be distributed throughout the City by gravitation. As no such body exists in this vicinity, which can be made available at an elevation high enough for our purpose, enterprise and perseverance must supply the deficiency, bearing in mind that it is not the communities most favored by nature which rise the highest in the scale of civilization."

The work had now so far progressed, that there seemed but little doubt of its final accomplishment. This view of it is taken by Mayor Howland, who, in his opening communication to the City Council of January 4th, 1864, thus again alludes to the enterprise:

> "The subject in the minds of the people, next perhaps in importance to that of the war, is the introduction into the City of a supply of pure water.
>
> The Report of Professor Chase, who was employed to examine the line of the stream which it is proposed to use, and to analyze the water, is full and definite; and so far as it relates to the character of the water and the formation of the valley for the purposes contemplated, must be satisfactory to all. The facility for storing a large supply of water, and the character of the ground upon which it is to be stored, are all that can be desired. All the natural features of the undertaking are in our favor; and it seems almost as if nature had anticipated the wants of man in the formation of the valley of the Acushnet for the purpose now under consideration.
>
> The important question then for us to consider, is the feasibility and expediency of availing ourselves of the advantages. This opens the whole subject. Many of our citizens are in favor of a vigorous prosecution of the work, while some express doubts of the successful operation of the enterprise, and others are decidedly adverse to the movement.
>
> The substance of the Report of Professor Chase has been made public through the daily journals; and the survey and estimates which are now in

course of prosecution will, it is hoped and believed, be completed sufficiently early to allow the City Council to lay the subject before the people so fully and so clearly, that they will be enabled to comprehend it in all its bearings; and when the time for their decision shall arrive, they will be prepared to render a verdict both sound and satisfactory.

If the measure commends itself to the favorable consideration of the citizens, and they so express themselves through that most potential instrumentality, the ballot-box, the City Council will probably consider themselves authorized to enter upon the prosecution of the work as soon as practicable. I hold myself, in my official position, ready at all times to promote and carry forward the wishes of the people, in this or in any other great measure having for its object the public good."

Following this communication, on the 14th of January, the usual Joint Committee* was appointed. The order authorizes all needful expenditures. On the 11th of February, another order provides for the printing of one thousand copies of the Report of the Committee of the former year, including Professor Chase's Report and that of the City Surveyor. The vote of the inhabitants upon the acceptance of the Act of the General Court was taken April 14th, 1864. There were *thirteen hundred and seventy-five* votes cast, of which *seven hundred and eighty-one* were in favor of and *five hundred and ninety-four* opposed to the undertaking.

The work was now in the hands of the Council, but there was little progress made during the year 1864. A map of the proposed New Bedford Water Works, prepared by George A. Briggs, City Surveyor, under the direction of the Joint Committee, was published with the Report of the Committee of 1863. It bears the names of the Committee of 1864.

We find no Report from that Committee.

At the opening of the year 1865, the subject was again presented to the City Council. Mayor Howland thus briefly alludes to it in his address to the Council, January 2d, 1865:

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* Committee, the Mayor, Aldermen Ladd and Perry, and Councilmen President Taylor, and Messrs. W. G. Taber, Bullock, Kingman and Knowles.

> "In April of last year, as you all recollect, the "Act for supplying the City of New Bedford with pure water" was accepted by our citizens, by a vote of 781 yeas to 594 nays. The Act is therefore within the control of the City, to be carried into effect at such time as the City Council may determine."

No Committee was then appointed.

In April of 1865 the City Council made a visit to the line of the proposed Water Works; and on the 20th of July following, an order was adopted which led to important results. By it a Joint Committee* was appointed "to make full enquiry as to the best source from which a sufficient supply of pure water can be obtained for the use of the City, the most feasible method of introducing the same, and the estimated cost of such introduction; and report the result of their investigations and enquiries to the Council at their earliest convenience."

In October an order passed the Council instructing the Committee to report in print, and on the 23d day of the following month the Report was presented.

The Report made by the Committee appointed July 20th, 1865, "to make full enquiry as to the best source from which a sufficient supply of pure water can be obtained for the use of the City, the most feasible method of introducing the same, and the estimated cost of such introduction," embraces the whole subject.

It includes the Report of the Committee; the Analysis of Samples of Water by Prof. G. I. Chase; and the Report made to the Water Committee by William J. McAlpine.

On the question of purity the Committee say:

> "In the early settlement of our City the water was undoubtedly good, pure, or nearly so; and it is asked why is it not now? The answer is obvious and conclusive. In cities the quality of water deteriorates from the simple fact, that with an increase of population, come of necessity a multiplicity of sink-drains, cess-pools, privies, decaying vegetables and other filth, which is daily emptied into the streets and yards. With this large amount of filth and de-

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* Committee, Messrs. Ladd, Knowles, Howland, Gifford, Kempton, Macomber, Chisholm and Hammond.

caying matter, the water, as it runs on the surface, or percolates through the earth, is brought in contact before it reaches our wells; and absorbing thereby various and poisonous qualities, it becomes unfit and unsafe to drink or to use for domestic purposes. Thus fouled and poisoned, who can doubt that it engenders disease, and impairs, more or less, the health and vigor of all who use it?

The water in most of our wells is hard, as will be seen by an analysis of Prof. Chase, or at least hard in comparison with the water of Ansel White's Pond, which has .815 degrees of hardness, while the water from Mayor Howland's well has 5.999 degrees of hardness. The water in his well is probably softer than it will average in the southern half of the City, and about a general average."

The Committee proceed to consider the question of "supply," "economy," and "source."

The Committee conclude by directing attention to the able Report of William J. McAlpine. They say:

"To aid in the investigation, your Committee were fortunate in securing the services of William J. McAlpine, Esq., an eminent civil engineer. Mr. McAlpine has had twenty years' experience in hydraulic engineering, has made that subject a specialty, and brings to the investigation a reputation, experience, judgment, and ability equalled by few, and surpassed by none. His opinions and estimates may be relied upon with implicit confidence.

In presenting Mr. McAlpine's Report, we ask for it a careful perusal and candid consideration. It is full, ample, complete.. It discusses, with marked ability, the whole question of 'water supply;' gives with clearness and force, the arguments for and against the several plans which have been presented, and the reasons which induced him, as he does, to 'recommend for adoption the Acushnet plan, substantially as it was submitted by Mr. Briggs.' In this conclusion your Committee cordially agree."

Professor Chase devotes the larger part of his Report to a statement in relation to the quality of the water from sources which may be availed of should the supply from the Acushnet prove insufficient. He says:

"You have reason to deem yourselves fortunate in being able to add to the supply of water from the Acushnet, should that prove insufficient, from other neighboring sources of so great purity. You will, of course, first draw upon Little Quitticus, then upon Snippatuit, and lastly, and only in case of necessity, upon Turner's Pond. It affords me pleasure to learn that your City has taken the preparatory steps for carrying out an improvement, which will not only tend to promote the health and comfort of every citizen, but furnish an essential requisite of an enlarged material prosperity."

The Report of Mr. McAlpine is so full and so extended, that it will be almost impossible to give even a satisfactory synopsis of the many parts into which it is divided. He examines the subject under the following heads:

1. Quality of the Water.
2. Common Wells.
3. Artesian Wells.
4. Advantages.
5. Objections.
6. Quantity Required.
7. Storage.
8. Description of the Plans—
    1. Harbor Dyke.
    2. Acushnet.
        The Conduit.
        Receiving Reservoirs.
        Modification of the Acushnet Plan
    3. Long Pond.
    4. Turner's Mills.
    5. Smith Mills.
9. Distribution.
10. Estimates of Cost.

This Report covers sixty-five pages of the printed Report of the Committee; and under each of the heads into which it is divided, examines with a clearness and fullness which can only be obtained by long experience and a profound and comprehensive knowledge of the subject, the different questions connected with the important public improvement then in contemplation. We have only space to present a few of the remarks bearing upon the general subject, which are contained in this able Report.

"The well water in this, as in all other cities, will show great impurities, while those of the wells, springs, and streams outside of the City, where the atmosphere is pure, and where the soil is remarkably free from injurious soluble substances, (and having been washed for ages is now a grand filterer,) should show, as they do by Professor Chase's analysis, great purity.

The water required for domestic uses should possess the following characteristics to the greatest extent, viz.: *softness*, *limpidity*, *equable temperature*, purity and abundance, and convenient distribution."

Of wells he thus speaks:

"Wells within the City, would of course be more seriously injured by the garbage found almost everywhere on the rear grounds of many of the houses, which is taken up in solution by the water flowing into the wells. Those waters also come in contact with the fæcal matter of privies and stables, and dissolve and absorb them, sometimes to such an extent as to injure the health of the persons using them. These contaminations are not the less real because they are not usually observed. The gases of this dissolving matter frequently give sparkling life to the water, and a small mixture of the earthy salts imparts a flavor, and with the temperature lowered by ice, induces persons to express a preference for *such mixtures*, over pure, but less palatable water."

Under the head of "advantages" we find the following remarks:

"With an abundant supply of pure water, distributed throughout the City, easily accessible at all times, cleanly habits are promoted and encouraged among all classes, but especially among the poor; disease is lessened, and in consequence more labor is given to increase the substantial wealth of the place. With pure water, always at hand, the craving for ardent spirits is lessened, and with it the diminution of the crimes and follies which follow in the train of dissipation."

In considering some of the objections urged against the proposed undertaking, he remarks as follows:

"It may be said in general terms, that the present examination demonstrates beyond all reasonable doubt, that an ample supply of pure and wholesome water can be procured and distributed to nearly every dwelling for domestic and manufacturing purposes, and for the shipping for the present and future requirements of the City, at a reasonable outlay, and that the revenue will repay the cost of maintenance, and contribute so far towards the interest on the cost, as not seriously to encumber or tax property, and that instead of keeping away settlers and business, the introduction of water upon this plan will bring new citizens and encourage additional manufactories, and thereby add to the wealth and lessen the taxes on the present property."

It has been assumed for the basis of the plans and estimates herewith submitted, a present supply of *two millions* of gallons daily, and a probable future demand for *three millions*, say within ten years.

The Storing Reservoir, formed by the dam across the creek on Wilson's Farm, will cover *three hundred* acres, and will contain *three hundred* millions of gallons, when the surface of the water is at a level of forty feet above tide.

Of late years the smaller cities have used cement pipes almost exclusively, and the experience of many years demonstrates their durability.

Cast iron pipes are liable to corrosion, and in some cases have been seriously obstructed thereby. The cement lined pipes are free from this difficulty, and they certainly will maintain the water in a more pure state than iron pipes.

I have no hesitation, therefore, in recommending their use for all except the pumping and large distributing mains.

Carefully considering all the circumstances of the case, I recommend for adoption the Acushnet plan, substantially as it was submitted by Mr. Briggs, and as herein presented."

The Report of a minority of the Joint Special Committee on Water was presented at the same time, and printed.

This Report gives great credit to Mr. McAlpine for the able manner in which he had investigated the subject, and gives full credence to his statements and conclusions.

It approves of all that part of the proposed undertaking that sets forth the Acushnet as the proper source of supply, and the plan of bringing the water by a brick conduit to the receiving reservoir near the railroad crossing.

This is called by Mr. McAlpine, and in the minority Report, the "modified" Acushnet plan. The Report concludes as follows:

"We believe that by this plan all the advantages will be obtained for the encouragement of all manufactures requiring the use of steam power, which is the great object of its introduction at this time, and by it we shall avoid the great additional expense of its general distribution by reservoir on the heights, pumping engines, pipes, &c. We do not believe the time has arrived for this great additional outlay, but at some future time, if the wants of the City require it, the water can be generally introduced without any disadvantage to the plan we recommend, as is shown by Mr. McAlpine's Report."

This "modified plan," by which it was proposed to bring the water into the reservoir near the railroad crossing, from whence it was to be led into the City by one main pipe, on as high a grade as it would naturally flow, was adopted by the Council.

Five hundred copies of the Report of the minority were printed by order of the Council.

On the day that the Report of the Committee was presented, an ordinance was introduced "to regulate the proceedings of the commission for supplying the City of New Bedford with pure water," and, on the 30th day of November, 1865, it was passed to be ordained.

This ordinance was drawn with much care, and fully met the exigency which rendered necessary its passage.

The Act of the General Court provided for the appointment of three Commissioners; and the ordinance declares that they shall be called the "New Bedford Water Commissioners," and shall be collectively entitled to a salary of fifteen hundred dollars.

The Ordinance points out certain methods of proceeding, when the Commissioners are called upon to exercise the powers conferred by the Act of the Legislature; provides for estimates to be made by them, for the information of the Council; directs that monthly reports shall be made of the proceedings of the Commissioners; and points out the method to be pursued, in drawing funds from the Treasury for the purposes of the Works.

Immediately after the passage of the Ordinance the Council, in convention, made choice of the Commissioners.

William W. Crapo, Warren Ladd and David B. Kempton were chosen.

The Commissioners being chosen, and the labor and responsibility devolving on them, it will be mainly from their records, and from the monthly reports presented by them to the Standing Committee of the City Council, that the future progress of the undertaking is to be ascertained.

The Board of Commissioners was organized on the 13th day of December, 1865. William W. Crapo was chosen Chairman; James B. Congdon was appointed Clerk of the Commission.

On the 14th, an appropriation of one hundred thousand dollars was made, for the purpose of carrying into effect the orders of the Council. As it was understood that the funds for this operation were to be obtained by the issue of Water Bonds, the necessary instructions were given to the Committee on Finance, that the Bonds might be prepared and disposed of to meet the calls of the Commissioners.

Mayor John H. Perry, in his address to the Council, January 1st, 1866, thus briefly alludes to the introduction of water:

> "The introduction of an ample supply of pure water has for a long time occupied the public mind.
>
> It is a matter that has a most important bearing on the future of our City. After very careful surveys by various Committees, aided by the best skill and experience in the country, it was ordered by the last City Council that a sufficient supply be brought in for manufacturing purposes. Gentlemen of well known ability and integrity were appointed Commissioners, to cause the work to be constructed. I trust they will receive your aid and support in its commencement and speedy construction. The question being thus far disposed of, it becomes your duty as well as privilege, to offer any inducement inviting skill and capital to locate here with us. Its further introduction and general distribution will be a subject for future consideration."

In accordance with a provision of the Ordinance "to regulate the proceedings of the Water Commissioners," on the 1st day of January, 1866, a Joint Special Committee on Water was appointed, consisting of two members of the Board of Aldermen and three of the Common Council.*

The great undertaking may now be considered as fairly commenced. A plan had been adopted, much more limited to be sure in its character, than the more ardent friends of the movement had hoped for; the work had been placed in the hands of three Commissioners, all of whom were prepared to devote the best energies of their minds to its performance; the representatives of the people had provided the means; and the State and Municipal authorities had, by law and ordinance, conferred upon the persons chosen for its management, all the authority necessary for their operations.

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*Gifford and Kingman of the Aldermen, and Pierce, Macomber and Knowles of the other branch.

1866, January 30th, the Water Commissioners made their first monthly Report to the Standing Committee of the City Council on Water. As the Report is an important one, and shows the character of the Reports made by the Commissioners every month to the end of their four years' service, we copy it in full.

REPORT.

"The Board of Water Commissioners has been organized by the appointment of William W. Crapo as Chairman. James B. Congdon has been appointed as Clerk.

Mr. George A. Briggs, the City Surveyor, whose services from time to time since the year 1861, have been employed in the work of surveys and in preliminary investigations, has been appointed Chief Engineer.

William J. McAlpine, Esq., has been designated as Consulting Engineer.

The mill property of Ansel White in Acushnet, embracing mill buildings, lands, dam, flowage rights and land under the pond, exclusive of machinery and fixtures in said mill, has been purchased, and a conveyance made to the City. The consideration paid for the above property was $8,800.

The mill property of Sylvanus Thomas, known as the "Whelden mill privilege," has been bargained for at a price regarded by your Commissioners as reasonable, and a deed of the same will soon be delivered to the City.

Arrangements have been made for the survey of the lands to be flowed by the raising of the dam, and immediate steps will be taken to procure the title to the same.

Although at this early date your Board cannot make any Report of extended operations, or actual results, yet the time since their appointment has been diligently occupied in a careful preparation for the duties assigned them, in making investigations and gaining information, valuable and important in the prosecution of the work.

Realizing the responsibilities attaching to them, and sensible of the magnitude of the proposed operation, your Commissioners have deemed it wise and prudent to devote sufficient time at the outset for a thorough examination of the work entrusted to them.

While it is, and has been from the beginning, the fixed purpose of the Commissioners, to adhere in the construction of the Works, to the plan approved by the City Government in the adoption of what is called the "Minority Report," yet they consider it among their duties to suggest to the City Council, such improvements, and recommend such changes in said plan, as, in their opinion, will increase the efficiency, add to the permanency and lessen the present and future cost of the Works. Believing that the citizens will expect of them more than a mere superintendence of the mechanical execution of a fixed plan, they have entered into a careful study and consideration of the whole subject, have personally consulted with men of practical and scientific experience, and have examined works of similar construction.

As the result of this investigation, your Commissioners are unanimously of the opinion, that an alteration in the plan of construction is desirable and expedient, and will result in great economy and efficiency.

This alteration consists in the construction, at the outset, of the "Wilson Dam," and without the delay contemplated by said Minority Report, and in the omission of a large amount of the proposed dredging and excavation of the bottom of the Storing Reservoir.

The advantages of this alteration in the plan of the work are:

1. An increased supply of the water.

The storing capacity of the reservoir will be largely increased, and an exhaustless supply for the present and future thereby secured, beyond the fears of the most doubting.

Your Commissioners do not press the alteration upon the ground of supply, for in their judgment sufficient water for the present wants can be obtained at Ansel White's Pond, but mention the fact of increased supply as one of the results to be obtained by the erection of the dam at Wilson's, and which in view of the permanency and future efficiency of the work would seem desirable.

2. An improved quality of water.

The dam at Wilson's will furnish a reservoir of twenty feet in depth at its outlet, while that at Ansel White's will furnish a depth of only about ten feet. Experience has demonstrated the fact, that the greater the depth of the water in the reservoir, the less the impurity of the water by its contact with mineral substances and vegetable decomposition. The heats of summer acting upon a shallow pond, produce vegetable growth and decay which render the water more or less impure. This vegetable growth and decay is diminished and ultimately ceases under a greater depth of flowage. Hence the conclusion, all other things being equal, that the greater the depth of the reservoir the greater the purity of the water.

In addition to this, experiments show that the quality of water in a reservoir differs at different depths, that sometimes the purer water is at the top, sometimes midway, and at other times near the bottom. The natural causes producing this need not here be discussed; but the fact is of importance, inasmuch as with an increased depth of water at the gate-house and well connected with the dam, the greater the facility for drawing our supply from the purer strata of water.

3. An economy in the cost of construction.

Your Commissioners understand that the modified plan of taking the water from Ansel White's Pond, instead of at Wilson's, was adopted, in a belief, that a much less expenditure of money would become necessary. But even this plan contemplated at some future time, the construction of the Wilson Dam, and the large expenditures supposed to be necessarily connected with the flowage of a new reservoir.

The large item of expense, the more embarassing on account of its indefiniteness and the impossibility of exact estimates, was in the "grubbing and cleaning," which was roughly estimated at $100,000.

This expenditure, to the extent proposed, your Commissioners concur in believing to be unnecessary, and more especially if the water be taken at Wilson's instead of at Ansel White's. This conclusion has been reached after a patient investigation and a faithful consideration of the subject, and has been aided by a personal examination of kindred works, and by the experience of practical and scientific men, who have had occasion to observe the effect of vegetable matter upon large reservoirs of water.

Your Commissioners find that no city or town has ever yet been supplied with water from artificial reservoirs, or from existing ponds where the flow line has been raised, but has experienced in the first years of its introduction the presence of impure water. This annoyance, only occurring in summer, and for a longer or shorter time according to circumstances, diminishes year by year until it entirely ceases. This impurity may be perceptible a few weeks each year for one, two or more years, and is, of course, dependent upon the amount of roots, plants, and other vegetation in the reservoir, which have to pass through the process of decay. No work of this kind has ever yet been constructed so thoroughly as to avoid entirely the evil. The grubbing and cleaning of any proposed reservoir, will in a measure remedy it simply by reducing the amount of vegetable matter which is brought in contact with the water, and thereby diminishing the time necessary to accomplish the purification. Yet where no grubbing and cleaning have been performed, (and the instances are exceedingly rare where money has been expended to any extent upon this part of the work,) in every case the water has become pure, and the imperfections of the first few years have entirely and permanently passed away.

The history of the Works at New Britain, Conn., is in point, as illustrating this position, from the extreme magnitude of the difficulty which we are considering, and its rapid and certain disappearance. Your Commissioners have visited New Britain, and personally examined these Works, and have received from F. T. Stanley, Esq., the able and efficient Commissioner who had charge of the construction, and Prof. B. Silliman, Jr., who repeatedly examined the condition of the water, clear and full statements of all the facts.

An artificial lake had been formed, over a mile in length, between two trap mountains about a third of a mile apart. No stream flowed into this artificial lake, which has been kept full by the rain-fall. The area now covered by water was densely covered with shrubs, bushes, and large trees, which were removed in the winter by cutting down what remained above the ice, leaving the stumps from three to four feet high. The soil was wet and boggy, with rank growth of aquatic plants. All this vegetation, together with the stumps and roots of the trees and bushes, was left undisturbed on the swampy surface. The swamp or bog mud beneath the roots was of very great depth and was left untouched. The result has been this: the decomposing of such vast amounts of vegetable juices and organic substances, in a soil favoring much confervæ growth, has produced an unpleasant effect upon the water. During the first year the water remained pure until about the first of June, when it became offensive to the taste and smell, and so continued for several months when it rapidly disappeared, and the water was entirely pure again. The next year this impurity came later and was of shorter duration and was less offensive, and so of each succeeding year. During the last summer the impurity was of only a few days' duration and hardly perceptible. It should be added, upon the testimony of Prof. Silliman, and also from the practical experience of the residents of New Britain who made use of this water during these stages of apparent impurity, that although unpleasant and annoying, there is nothing in the water at these times harmful or noxious, or in any way detrimental to health.

The case of New Britain is an extreme one in many particulars. There is nothing in the reservoir made by Wilson's Dam, which would approach it in these circumstances leading to impurity of water. The instance cited and the whole history of Water Works, demonstrate that the annoyance alluded to, is a self-limited one and soon disappears.

Independent of any expenditures for grubbing and cleaning, the difference in cost between taking the water at Wilson's and at Ansel White's, is (upon the basis of estimates made by Mr. McAlpine,) the sum of $3,690, and is computed as follows:

ADDITIONAL EXPENSE INCURRED BY DAM AT WILSON'S.

Difference in road filling at Ansel C. White's,	$1,000	
20,000 c. yds. embankment, at 30 cts.,	6,000	
4,000 c. yds. puddled, at 30 cts.,	1,200	
1,000 c. yds. wall, at $3.00,	3,000	
4,200 c. yds. excavation, mucking, &c., at 30 cts.,	1,260	
		$12,460

DEDUCT EXPENSE BY DAM AT WILSON'S.

1,000 c. yds. facing dam, at 20 cts,	$200	
150 c. yds. slope wall, at $5.00,	750	
Cement oval pipe, 3,800 ft., at $1.50,	5,700	
7,000 c. yds. earth works, at 25 cts.,	1,750	
3,700 feet grubbing for pipe, at 10 cts.,	370	
		$8,770
Difference in cost,		$3,690

In the above, no estimate has been made for cost of land flowed by the lower reservoir, as both plans contemplated its present purchase.

Your Commissioners are unanimous and decided in their convictions, that the best interests of the work will be promoted by the building of the Wilson Dam and taking the water at that point. The earlier in the history of the work this is done, the sooner will the imperfections in the quality of the water cease, while at the outset, for all its uses along our wharves and for manufacturing purposes, no inconveniences will be experienced; and when the period for general distribution arrives, the difficulty will, in a great measure, or entirely. have ceased to exist. Your Commissioners would respectfully suggest the consideration by the Water Committee, of the opinion above expressed, and would urge that whatever action is taken upon the same by the City Government, should be prompt. The time has arrived when contracts should be made for the work, and if any change in the plan is deemed advisable, it should be made without delay."

Proceeding in accordance with the recommendation of the Water Commissioners, the Council adopted an order February 1st, allowing them to make such alteration in the plan of construction so far as taking the water from Ansel White's Dam, or at the proposed dam at Wilson's, as in their discretion they might deem most expedient, and gave them authority to exercise their own discretion as to the extent of grubbing, excavating and dredging the proposed reservoir.

In their second monthly Report, dated March 1st, 1866, the Water Commissioners state that George A. Briggs, Engineer-in-Chief of the Works, whose appointment was last month communicated, entered upon the dischage of his duties on the 1st ultimo, at a salary of twenty-five hundred dollars a year. He had been constantly engaged in making the surveys and plans required as preliminary to the contracts soon to be entered into for the various operations upon the Works.

They state in the conclusion of the Report, that they are carrying forward the work with all the expedition in their power. By consultation, enquiry and correspondence, they are constantly engaged in perfecting their plans and specifications, preliminary to the issue of proposals for contracts for the execution of the different parts of the work.

It appears by the third monthly Report of the Commissioners, dated April 4th, that during the month of March the work of preparation had made good progress. A contract had been made for cleaning the Storing Reservoir, and cutting the wood; a visit had been made to New York for the purpose of advising with the Consulting Engineer; and forms for contracts and specifications for Storing Reservoir, Brick Conduit and Receiving Reservoir were prepared and printed.

The Commissioners also state:

> "That the preparation of the drawings for the different parts of the Works has been going on during the month. These plans, they say, forming as they do important portions of the specifications, require to be clearly, accurately and artistically drawn; and an inspection of them will, we think, satisfy you, that with regard to them, the Engineer and his Assistants have fully met the requisitions of their position."

In their fifth monthly communication to the Water Committee, which bears date June 11th, 1866, the Commissioners state:

> "That on the 19th of May, in the exercise of the authority conferred

upon them by the law, they took possession of certain tracts of land, the property of Edward R. Ashley. The possession of this land was necessary for the prosecution of the Works, and the owner was absent at sea. There being no person with whom a contract could be made, the Commissioners were obliged to exercise the authority conferred by the 'Act for supplying the City of New Bedford with pure water,' to place them within their control."

We give some further extracts from this Report.

"Some progress has been made in the preliminary operations of beginning the Main Works of the undertaking.

A contract has been completed for raising the road at Ansel White's Dam. This has been made with Mr. Ansel C. White, and the work has already commenced. The Committee are respectfully referred to the contract on file for the particulars, which are too numerous to be given in this Report.

The building of the Storing Reservoir Dam is also under contract. It has been taken by George W. Lobdell. This contract, like the preceding, is made up of a great number of particulars, which it would be impossible to set forth in a Report of this character.

The contract is on file, and like the other documents of the same character, always accessible to the Committee.

The contract for the remaining parts of the Works are not yet completed. Some progress has, however, been made, and we have some grounds for the expectation, that our next Report will contain the information that this 'consummation so devoutly to be wished,' has been attained."

In their next monthly statement, dated July 6th, the Commissioners speak of the progress made in clearing the Storing Reservoir, and raising the road at Ansel White's Dam. They also inform the Committee that contracts have been entered into for the construction of the Conduit and the Receiving Reservoir.

The next (July 28th,) Report is brief, and concludes as follows:

"For the Works, as far as the construction has been entrusted to the Board, our contracts are now complete; and we trust that the important undertaking will continue to progress to a speedy and satisfactory consummation."

The Report for November is one of great importance in the history of the Works. The operations thus far had been carried on in accordance with the limited plan adopted by the Council, by which the introduction of water was to be confined to those portions of the City which could be reached by gravitation. There was to be a Storing Reservoir, Conduit and Receiving Reservoir. The Commissioners, seeing that the time had arrived for making a change in this plan, if a change was desirable, made a careful examination of the subject, and on the 20th day of November sent to the Water Committee the following Report:

"Numerous enquiries having been made by members of the City Government and by citizens, with reference to the time of completion of the Works entrusted to our charge, we beg leave to report as follows:

We have now under contract and in process of construction, the Storing Reservoir, the Conduit, and the Receiving Reservoir. When operations were commenced it was expected that these portions of the Water Works might be completed during or before November, 1866. It was soon found, however, that this was impracticable,—it being impossible to procure the required material and labor.

We now expect that the work, down to and including the Receiving Reservoir, will be fully completed by the Autumn of 1867.

No action has yet been taken by the Board for the distribution of the water. The authority given us by the City Government, includes the distribution of water by gravitation.

The unavoidable delay in the consummation of the contracts made any immediate action for distribution unnecessary, as the small amount required by this plan could easily be accomplished during the coming Summer.

We have thought, that should the City Government desire a more general distribution of water, it would be much more advantageous to contract at one time for the whole, rather than for the limited amount required by gravitation, to be followed soon after by contracts for a more extended distribution.

We have been called upon to furnish an estimate of the cost involved in a distribution throughout the City.

The plan recommended by Mr. McAlpine, embraced twenty miles of pipes. We have in our estimate placed the distribution at ten miles. The work required in addition to those already under contract, consists of the construction of an Engine-House, Chimney and Boiler-House, Engines, Pumps and Wells. Also a Distributing Reservoir, and lands for the same, and pipes for Pumping-Main and for distributing the water.

We have taken the quantities as stated by Mr. McAlpine, and give present estimates of cost, viz:

Engine-House, Chimney and Boiler-House,	$15,000.00	
Pumping Wells,	10,000.00	
Engines and Pumps,	40,000.00	
2250 feet of Pumping-Main,	20,000.00	
Distributing Reservoir, without land,	26,000.00	
Ten miles of Pipe for distribution and laying the same,	115,000.00	
		$226,000.00

The above does not include the cost of land for Distributing Reservoir. In the Report of Mr. McAlpine, nine thousand dollars was estimated as the cost of nine acres. This sum we believe to be very much more than the actual cash market value of lands in that vicinity, and more than double the actual sales during the last five years.

At the same time, in this as in all cases of land damages, a portion of the land owners will place unreasonable and grossly excessive prices upon their property when wanted for public improvements. If we are to give an opinion of the cost of the land required, based upon actual sales, we should estimate the cost at five thousand dollars. If we are to give the prices demanded by the land owners, then three, and perhaps four times this amount should be stated.

To the above should be added for contingencies, engineering, expense of hydrants, stop-cocks, &c., &c., and the various fixtures required, the sum of thirty-five thousand dollars.

The total cost, as above, amounts to two hundred and sixty-one thousand dollars; and this we consider ample to complete the Works to the extent of ten miles of distribution. In the above is not included the cost of the work already under contract.

Should it be the wish of the City Government to proceed with the distribution the coming season, it is of great importance that early action should be taken by them, and the necessary authority conferred upon the Commissioners without delay. Time is needed for inquiry and preparation. There are numerous questions affecting the mode of pumping the water, and the power to be employed, and also the kind of pipes to be used in the distribution, the construction of hydrants, &c., &c., which require careful and pains-taking investigation.

Much time also is required in the actual construction, after plans have been matured and contracts made.

Should authority be given to the Commissioners to proceed with the general distribution, embracing ten or twenty miles of pipe, the work probably could be completed and the water ready for the citizens in the Autumn of 1868.

The Water Committee promptly laid this important document before the Council; and on the 20th of December, 1866, the whole aspect of the enterprise was changed by the passage of the following order:

"IN COMMON COUNCIL,
December 20th, 1866.

Ordered, That the Board of Water Commissioners be and they are hereby authorized to continue their construction of the Works, and at such times as seem to them judicious, to make all necessary contracts for the pumping of the water, for a Distributing Reservoir, and for laying Distributing Pipes to the extent of ten miles through the City.

Adopted in concurrence."

Mayor John H. Perry, in his Address to the City Council, January 7th, 1867, thus speaks of the progress and condition of the Works:

"I stated in my Address one year ago, that the City Council had ordered the introduction of a supply of pure water for manufacturing purposes in the lower parts of the City, and had appointed Commissioners to carry into effect that portion of the work. I am satisfied the gentlemen so appointed have acted cautiously, wisely, and for the best interests of the City.

The high cost of material, in fact the utter impossibility of obtaining the requisite quantities, has caused unavoidable delay in its construction. I am happy to say that arrangements are now perfected that will allow of its speedy completion. The Commissioners have since been authorized and empowered to cause its general distribution throughout the City, and to make contracts for the same, when in their judgment it may seem for the best interest of the public. Feeling that the matter is in able and honorable hands, I trust we may have no cause to regret the course that has been taken in authorizing the project."

The Committee* provided for in the Ordinance was appointed January 7th.

With the opening of the year 1867 the enterprise for the introduction of the water of the Acushnet, and its distribution through the City, was in the hands of the Commissioners in its full extent. By the change that had been made, the work had doubled in importance and extent, and involved an expenditure of a much greater amount than was contemplated by the plan first adopted by the Council. An Engine lot, an Engine-House, a Pumping-Engine, a Distributing Reservoir and ten miles of Street Mains were now added to the Storing Reservoir, the Conduit and the Receiving Reservoir, as constituent parts of the undertaking.

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*Aldermen Gifford and Kingman, and Councilmen Pierce, Hathaway and Gordon.

A much greater amount of care and labor, and a greatly increased responsibility now rested on the Commissioners.

On the 9th day of January, 1867, they placed in the hands of the Water Committee their *twelfth* monthly Report, which concludes as follows:

"Having in our Report of November given a full examination of the questions upon which the action of the Council was based, we are now only called upon to say, that this important enlargement of the operations of the Commission will receive our immediate, careful and earnest attention."

The Commissioners' Report of July 9th, 1867, (eighteenth,) contains interesting and important information. We give copious extracts:

"During the past month, the Commissioners, in company with Mr. McAlpine, the Consulting Engineer, have visited the Water Works of Brooklyn, Jersey City, Philadelphia, Pittsburg, Cincinnati, Louisville, Chicago, Detroit, and Hamilton in Canada. The principal object which they had in view, was an examination of the different modes of pumping water.

The conflicting opinions of mechanical engineers, and the diversity in the operation of engines and pumps, in raising water, made such an investigation not only advisable, but necessary.

They have endeavored, from an inspection of the practical working of engines and pumps in actual use, to form a correct opinion of the merits of the several plans adopted by others.

Your Committee will readily see the importance of a correct conclusion upon this branch of our work. Not only the original cost of the construction of the engine and pumps, but also economy in operating them for many years are to be wisely considered.

The main expenditure of the Works, after the construction is completed, will arise from the pumping of the water into the Distributing Reservoir; and if the apparatus for this purpose is insufficient or extravagant in operation, then the supply of water must be unreliable or unduly expensive.

Your Commissioners believe, that the exceedingly careful and thorough examination and comparison of the different engines used in other cities and towns, will prove of advantage in determining the perplexing questions which arise in this branch of the construction.

During the trip, the attention of the Commissioners was also directed to the subject of distribution, fire hydrants, and the various matters incident to the work in their charge.

The Commissioners further report, that the clearing of the Storing Reservoir is about completed; that the Dams at Ansel White's Pond and at Wilson's are substantially finished; that the work upon the Conduit is progressing, and an important culvert at Morse's Mill is in a state of forwardness, and that the construction of the Receiving Reservoir is progressing satisfactorily.

The continuous rains during the Spring months have interfered with the working of the brick-making for the Conduit, and hence delayed somewhat the execution of that part of the work, but the Commissioners believe that the contractor is urging forward the brick-making, (now being done on Martha's Vineyard,) and that the laying of the brick will commence at an early day."

Neither the records or the Reports of the Commissioners nor the proceedings of the Council for the next month, contain anything of much importance. In their twentieth monthly Report, September 9th, the Commissioners communicated to the Committee the fact, that being unable to purchase the land for the Distributing Reservoir and for the Engine-House, without paying for it prices much beyond the value of the property taken, as they had estimated it, they had been obliged, under the authority of the Act of the General Court, empowering the City of New Bedford to construct the Works, to *take* the land which they could not purchase for what they believed to be a full compensation.

All the land had now been acquired that was wanted for the Distributing Reservoir, and operations for its construction would immediately commence.

Contracts had been made for the construction of the Engine-House, Pump-Wells, &c.

Plans for the proposed Engine-House had been prepared by E. D. Lindsey, Architect. Operations upon the Conduit and the Receiving Reservoir were being vigorously prosecuted; and allusion is made to the fact that the Dam at the Storing Reservoir had been completed and specifications prepared for the Engine and Pumps. The fact is announced that the Storing Reservoir is now full.

In a special communication to the Water Committee bearing date October 9th, 1867, the Commissioners call attention to the fact, that on the 30th day of November of that year the term for which they were appointed would expire. They say that

> "The importance and magnitude of the work, and its unfinished condition, require that some action should be taken by the City Council, either by an additional Ordinance authorizing the appointment of "such agents" as contemplated by the Act, or in some form indicating the manner in which the completion of the Works shall be prosecuted.
>
> Your attention is thus early called to the subject, in order that ample time may be had for its consideration, and for the passage of any Ordinance which may be deemed necessary."

Immediate attention was given to the subject, and on the 21st day of November an Ordinance was passed which authorized a new choice of Water Commissioners, and a continuation of their office "for two years or until the Aqueduct and Works should be completed," and on the same day the old board was re-elected.

In their monthly Report of October 9th, the Commissioners inform the Committee that a satisfactory contract for a Pumping-Engine and two steam boilers had been made with George W. Quintard, of New York.

On the 9th day of December, the Commissioners elected under the Ordinance of November, made choice of William W. Crapo as their Chairman. James B. Congdon was reappointed Clerk.

Their *twenty-third* monthly Report is of that date. They inform the Committee, that on the 6th day of December they contracted with George H. Norman, of Newport, for the Pumping-Mains and Distributing Pipes, and for laying the same, upon terms which were satisfactory.

The remainder of the Report we give entire, with the exception of the details of the expenditures up to the date and the estimates for future operations.

"The term for which your Commissioners were originally elected, having expired on the 30th of November last, the present seems a proper occasion to report to your Committee the results and expenditures of the past two years, the present condition of the work, and the plans and requirements for future operations.

There have been completed, to our satisfaction, the Storing Reservoir, Gate-House and Water-Way, and the raising of the road which separates the upper and lower sections of the Storing Reservoir.

The clearing of the Storing Reservoir has been nearly completed, according to the plan adopted by the Commissioners.

The work upon the Conduit leading from the Storing to the Receiving Reservoir has not progressed as rapidly as we had expected at the beginning of the year. Of the 5⅜ miles required, the brick pipe has been laid a distance of about 4,400 feet, and trench excavation has been partially made for an additional distance of about 1,100 feet. The delay in this part of the work has been extremely annoying to the Commissioners, and every effort has been made by them in urging forward its completion.

One cause of the slow progress which has been made, may undoubtedly be attributed to the unfavorable season for making brick, and the difficulties which have attended their transportation. So far as the work on the Conduit has progressed, we have no hesitation in saying that it has been faithfully executed.

The Receiving Reservoir is nearly completed; a portion of the slope wall and a small amount of excavation and puddling remaining to be done.

Work has been commenced, and is progressing satisfactorily upon the Culvert leading from the Receiving Reservoir to the Pump-Well and Engine-House foundation.

The Distributing Reservoir is in process of construction. The work upon it, temporarily suspended during the Winter, will be resumed in the Spring.

The Pumping-Engine and Pumps are being built, and will, without doubt, be ready for use before the completion of the Conduit.

The contract for the Distribution Pipes requires the completion of this branch of the work on the first day of August next.

The Commissioners have arranged all their contracts with a view to the completion of the entire work and the introduction of water during the coming Autumn. Every effort will be made by them to secure this result.

The monthly Reports which have been rendered to your Committee have given the items of the disbursements already made. A repetition of these items is now unnecessary.

The total expenditure up to this date is $127,387.44. In making an estimate of the amounts that will be required to complete the work, the Commissioners find themselves unable to state satisfactorily one of the items of expenditure. They refer to the matter of land damages. In estimating the quantity and cost of materials and labor in the construction, they can approximate with considerable accuracy to the actual expenses, but the sums required to liquidate the claims for right of way of Conduit, and land for Distributing Reservoir and Engine-House, must necessarily be uncertain. Your Commissioners have earnestly endeavored to arrange for the purchase of land and right of way, without resortin to the takin of them under the Statute, and have in all cases manifested a disposition to give the most liberal compensation. But there is, they regret to say, a disposition on the part of a number of land holders to insist upon the most exorbitant terms. Prices are insisted upon which, in negotiations between individuals, the owners would not think of asking, and which are three and four fold the actual value of the premises or of the amount of damages. In such cases, the Commissioners have felt it to be their duty to enter upon the lands which were needed in the construction, and leave the owners to their remedy for compensation as provided by the Statute. This course involves costs, expense, and much annoyance both to the owners and Commissioners, but the proper protection of the City against injustice and extortion renders this procedure necessary.

In addition to the sum of $127,387.44 already expended, there will be required to complete the work the sum of $360,814.13.

There has been placed to the credit of the Water Works by the City Council, the sum of two hundred thousand dollars. Of this sum there remains unexpended at this date, $72,612.56. In addition to this amount now on hand, there will probably be required during the coming season the further sum of two hundred thousand dollars.

Your Commissioners would not, in the present condition of the work, advise loans in excess of this amount until nearer its completion. The present balance will be sufficient to meet the expenditures of the Board until July next.

The Committee are already aware, that upon the completion of the Dam in July last, the water was collected in the Storing Reservoir, and are also aware of the rapidity with which the Reservoir was filled.

The observations which the Commissioners have been enabled to make during the progress of the work, confirm the views previously entertained, that the supply of water will be ample, not only for the present, but future wants of the City, and that any apprehensions that the enterprise, when completed, will be of little value, on account of the limited supply of water, are groundless."

Such was the condition of this undertaking at the close of the year 1867.

There had been many unexpected obstacles to surmount, many vexatious delays to encounter; but the work had made a fair progress, and was now entered upon in all its branches.

On the 6th day of January, 1868, Mayor Andrew G. Pierce made his Inaugural Address to the City Council. We quote that part of it which is devoted to the Water Works:

"The introduction of water into the City is the most important undertaking in which our Municipal Corporation has been engaged. The large outlay attending it, and the great advantages hoped to be derived from it, necessarily make it a subject of general interest in our community. The expediency and wisdom of this enterprise it is now too late to consider. The City is fully committed to the work, not only by the sanction of the popular vote of the citizens and of successive City Councils, but by the expenditure of large sums of money. From the commencement, I have been an earnest advocate of the introduction of water, and believe that when it shall have been distributed, and the citizens have had an opportunity to experience its benefits at their homes and in the various business undertakings requiring its use, its bitterest opponents will be the least willing to return to their own mode of supply.

The rapid filling up of the Storing Reservoir, after the gates at the same were closed, attests the wisdom of those who selected the source of supply, and fully corroborates their statement that this supply of water would be abundantly ample for the present and future wants of the City.

The Report of the Commissioners shows an actual cash disbursement, up to the present date, of $127,387.44.

Contracts are already made which will call for an expenditure of $284,814.83; and in addition, there will be required for Engine-House, duplicate Engine, land damages and incidentals, the estimated sum of $76,000.

The original estimate made by the Engineer and the Board of Water Commissioners placed the total probable cost of the work, with ten miles of distribution, at $500,000. Although the increased price of labor and materials have added somewhat to the cost of certain portions of the work, yet those in charge of the same are sanguine that the total expenditure will not exceed the amount originally contemplated.

I am satisfied that the execution of this work is in faithful and able hands; that the Commissioners have diligently labored to secure thoroughness and durability, with prudence and economy in the expenditure of money, and that they have striven for the expeditious completion of the work. As in all such large undertakings, there has been more delay in forwarding the work than some ardent persons have desired, but from my own personal observation, I believe the delay has not proved detrimental to the City; since the work has been prosecuted with increased faithfulness and at a smaller cost. It is hoped that the present year may witness the introduction of water; for besides the impatience of many of our citizens to avail themselves of the use of it, the safety of the City in event of a conflagration is dependent upon an increased supply.

Were there no other reasons, this necessity for water in the extinguishment of fires should urge forward this work with all prudent rapidity. It will be for you to provide the means for the further prosecution of the work, agreeable to the Ordinances of the City."

The Water Committee for 1868 consisted of the Mayor, Aldermen George H. Dunbar and Elijah H. Chisholm, and Councilmen Horatio Hathaway, President of the Common Council, John W. Macomber and William Gordon, Jr.

On the 15th day of February, 1868, the Dam at the Storing Reservoir give way, which accident greatly delayed the operation and largely increased the expense. The Report of the Commissioners dated March 28th, gives a full and clear account of the accident, its causes and consequences.

After stating that the weather had delayed the work, they say:

"On Saturday, the 15th day of February, we met with a serious and unforeseen accident, in the giving way of the Storing Reservoir Dam, around the Gate-House. By this break in the Dam, about three thousand cubic yards of earthwork has been carried away, and the stone masonry forming the Gate-House and Culvert has been undermined and displaced.

This unfortunate break occurred in the Gate-House and Culvert foundations, and is doubtless to be attributed to the action of the water upon quicksand not sufficiently guarded. The weather has not been suitable to undertake the removal of the masonry, and hence we cannot speak with that particularity of detail of the causes of this failure which we shall be enabled to after the rigid examination attending its repair.

Beyond the damage done to the Dam itself, but slight injury was sustained by the sudden flood of so large a body of water rushing from the Reservoir. The bridge in the highway near the residence of Eben Leonard was much injured, but the same has been temporarily replaced and the permanent rebuilding of the bridge has been commenced.

The damage done the archway under the road forming the upper Dam, is in process of repair.

It will be necessary to take down and rebuild the Gate-House and Culvert, and to rebuild that portion of the earthwork carried out by the water.

This work we shall enter upon at once, and we shall avail ourselves of the highest professional skill and the most practical experience which it is in our power to obtain.

By this accident we shall lose whatever benefit might have been derived in the interval of repairs from a flowage of the Reservoir in the purification of the water, but no delay will be occasioned in our purpose to introduce water into the City during the coming Autumn.

Before leaving the subject it is proper for us to add, that although this accident is exceedingly unfortunate both in its cost of repairs and its interference in the plans of the work, yet we cannot candidly impute blame to any one. Great care was taken in preparing the foundation, and the stone masonry was ample in size and excellent in the quality of the materials.

We have had in the break of the Dam simply the experience of most other cities, in the construction of Water Works; and we hope to learn, as other cities have learned, by experience, the nature of the foundation and the particular obstacles we have to contend with in securing a reliable and permanent structure.

The failure of the Dam, at this point, does not imply insecurity in its remaining portions, there being at this time, no indications, by settling, of any weakness therein.

With the opening of Spring weather the general work of construction will be commenced and prosecuted with vigor."

Some doubts having been felt as to the validity of the election of Commissioners under the Ordinance of November, 1867, measures were taken to remove them by obtaining from the General Court the necessary legislative sanction to the proceedings. An Act was passed on the 11th day of March, 1867, by which the choice of the Commissioners and all acts performed by them subsequent to such choice were made valid.

The Report for April informs the Committee that a contract had been made for the erection of a Boiler and Engine-House. This arrangement was not consummated, the contractor refusing to sign the contract. In June another contract was made for the masonry of the building, and with other parties for the iron work, carpentry, &c. The Commissioners thus speak of the stormy weather which had greatly retarded their operations:

> "We have to report that the unusual stormy weather and the excessive and continuous rains which have attended our operations since the opening of Spring, far exceeding the experience of former years, have greatly retarded our progress. Every effort is being made by us to press forward the work, notwithstanding the serious difficulties which the contractors have been compelled to encounter."

The *thirty-first* monthly Report of the Commissioners is dated July 29th. They state that the laying of the Distribution Pipes commenced on the 15th of that month. As this Report alludes to an important subject we give it in full:

> "The laying of the Distribution Pipes was commenced July 14th, and will be continued until the amount of distribution authorized by the City Council has been completed.
>
> If the promises of the various contractors are realized, and the obligations assumed by them fulfilled, the water will be let into the Distribution Pipes during the coming Fall. To this end the work is being urged, and the Commissioners will spare no effort in accomplishing this result.
>
> The question has arisen how far the powers of the Commissioners extend in the matter of supplying the water to the consumers. It would seem that their duties cease upon the completion of the 'Aqueduct and Works;' that, when the Mains in the streets are filled with water, they have no power to regulate its use or establish rates therefor. If this be so, and the Commissioners have no desire to assume any authority, nor perform any duty not clearly incumbent upon them, then they respectfully suggest that the City Government, at an early day, consider the following questions:
>
> 1. The mode of tapping the Main Pipes.
>
> 2. The character of the Service Pipe to be used, whether lead, or lead lined with tin, or iron, or cement lined.
>
> 3. The apportionment of the expense of laying Service Pipe, as between the City and the abuttors; and
>
> 4. The rates of charges and regulations concerning the use of water.
>
> It is quite important that a uniform system of tapping the Mains and leading the water to the houses should be adopted. This system should be as perfect as possible, and in order to secure this result, care should be taken in the investigation.

Much of the work connected with the Service Distribution can be performed by our own mechanics, if time be given them for making the articles required."

No definite action was taken by the Council in relation to the subject of the Commissioners' Report.

The second arrangement for the erection of the Engine and Boiler-House having fallen through, a new engagement was made under which the work was finally and most satisfactorily accomplished.

At the close of the year, the Commissioners, as had been usual with them, presented to the Water Committee, and through the Committee to the Council and the people, a summary of their operations. The Report is dated December 28th, 1868. All parts of this statement are important and interesting and we give it nearly entire:

"In our Report of one year ago, we intimated our expectation that the past season would witness the introduction of water into the City. So anxious were we to accomplish this, that we made a change in the contract for building the Conduit, making an advance in the prices therefor. All the contracts, at the beginning of the year, were so arranged that we had reason to hope, from the reputation and energy of the contractors, and the express stipulations of the contracts, most of which carried a penalty in case of non-completion at the dates designated, for a completion of the work during the year. In this we have not been successful. The unprecedented wet weather of the Summer has seriously interfered with the contractors, and the scarcity of laborers has also been urged by them as an excuse for this delay.

The work upon the Brick Conduit has been carried on, during the past season, between the City and the Head-of-the-River. The greater portion of this section has been finished. The Brick Pipe has been laid, during the year, a distance of about 9,200 feet, making, with the distance of last year (4,400 feet), an aggregate completed of about 13,600 feet. Nothing has been done to the Receiving Reservoir during the year. The amount of work necessary to complete it is comparatively small, and can be accomplished in a few weeks whenever undertaken.

The Culvert leading from the Receiving Reservoir to the Pump-Well, and also the Pump-Well and Engine-House foundations have been completed. The execution of this work, apart from the delays attending it, has been satisfactory to us.

The walls of the Engine and Boiler-House are finished, and the roof is now being placed upon the building. The style of the building and the workmanship upon it are creditable to the architect and the builder.

The Engines and Boilers and Pumps have been received and are now being placed and adjusted at the Engine-House. No test of their powers and efficiency has yet been made.

Work at the Mount Pleasant (Distributing) Reservoir has progressed with great slowness during the year, but the embankment and puddling thus far we believe to have been done with faithfulness. It will require about three months of labor and good weather to complete this part of the work.

Between the Engine-House and Distributing Reservoir about 1,700 feet of the Pumping-Main of cast iron (16 inches in diameter) have been laid. About 500 feet in addition will be required to complete the Pumping-Main.

Nearly all of the Distribution Pipes called for, by the vote of the City Council, have been placed in the streets.

We have no means as yet of testing the cement lined pipes, which constitute the larger proportion of our distribution. Yet we are of the opinion, which is confirmed by that of experienced persons from other cities, who have examined the pipes as put down in our streets, that the firm material upon which these pipes rest, and the skillful and painstaking manner in which the contractor has performed his work, will secure to us a satisfactory and serviceable distribution. In fixing upon the streets to be used for these pipes, we have had regard not only for the probable wants for consumption of the water, but its availability for the extinguishment of fires.

The subject of Service Pipes, leading from the Mains to the buildings, has had our attention. We shall be prepared at any time to confer with the Committee of the City Council in relation to the adoption of some uniform method of taking the water from the Street Mains. It will be necessary for the safety of the water pipes to make some more stringent Ordinances, or to enforce more rigidly those now existing. Already we are meeting with difficulties in the interference with the pipes from the free, unregulated and unauthorized opening of the streets by abuttors for drains and other purposes. In the month of February last we met with a serious accident in the breakage of the Dam at the Storing Reservoir. As this accident has been the subject of a special communication it is unnecessary now to repeat the statement heretofore made. The repairs which have been going on during the Summer and Autumn are nearly finished. The expenditure upon this, part of the work has been very large and greatly in excess of the original estimates. This increased cost has arisen partly from the unfavorable season, but more especially from the unanticipated and serious difficulties encountered in procuring a safe and reliable foundation. We have felt it our duty, in view of a possible repetition of this disaster, to spare no pains and to omit no precaution, even although it involved the outlay of a larger sum than might originally have seemed sufficient. The Dam is now so far completed that the Storing Reservoir can be filled whenever it is desired. The total expenditure up to this date is $347,844.65. We estimate that the completion of the work will require a further outlay of $172,449.16.

In our estimate we have omitted the amount which may be required for land damages, for the reason that we know of no rule by which to compute them. We have endeavored faithfully to settle all claims for flowage, right of way and land for Reservoirs, without recourse to legal proceedings, but in some cases we find the views of owners so extravagant and excessive that we have deemed it prudent and necessary to refuse the payment of the amounts demanded. With the great majority of land owners, however, we have found no disposition to ask for unreasonable damages, and we have, by allowing liberal compensation, settled a very large proportion of these claims. The amount of unexpended appropriations now standing to the credit of the Commissioners, is $52,155.35. In addition to this sum there will be needed during the coming year appropriations sufficient to complete the work."

Mayor Andrew G. Pierce, in his Address to the City Council, January 4, 1869, thus introduces the subject of the Water Works to the attention of that body:

"Contrary to the expectation entertained one year ago by the Water Commissioners in charge of the Water Works, the past season has not witnessed their completion. I believe that every effort has been made by them to secure the early introduction of water into the City. The causes for this delay have been apparent in the unusually unfavorable season for such work, and the alleged scarcity of laborers. I consider it of great importance that this work be accomplished at an early day. The increased safety from fire, and consequently the decreased cost of insurance on property, render it a matter both of wisdom and economy, that we make available without delay, this important enterprise. I am satisfied that the persons who represent the City in this department, are faithful and earnest in their endeavors, and that no efforts will be spared by them in the efficient and economical construction of the Works. The monthly Reports of the Commissioners will furnish to you all necessary information relating to the progress and probable wants of this department."

The Mayor, with Aldermen Cornell and Chisholm, and Councilmen Hathaway, Hitch and Mackie constituted the Water Committee for the year 1869.

We find nothing that seems to call for notice in this brief history of the introduction of water into our City, until we take up the Report of the Commissioners for the month of April. It is dated May 8th, 1869. This report states the circumstances attending a change of construction for the Distributing Reservoir. This was rendered necessary that their might be no delay in the distribution when the other portions of the work were completed. The Report speaks of the construction of the Conduit and Receiving Reservoir as progressing favorably. It states that the gates at the Dam had been closed and that the Pond was filling.

In August the Commissioners again call attention of the Water Committee to the subject of the necessary enactments on the part of the Council, that the Works may be put into operation. They say:

> "The Commissioners, in view of the fact, that the time has fully arrived for such action on the part of the City Council as will be required before the Works can go into operation, have caused to be prepared two Ordinances which they herewith submit to the Committee for their consideration.
>
> In their preparation, advantage has been taken of the experience of those cities of our Commonwealth which have Water Works now in operation; and it is hoped and believed that the labor which has been bestowed upon them will aid the Committee and the Council in the work of establishing such rates and regulations as the success of the Works and the interests of the City demand.
>
> They would respectfully suggest, that it appears important to them, that there should be as little delay in the establishment of the needful Ordinances as is possible, consistently with the attainment of clearness and wisdom in their provisions."

The "Ordinance to provide for the establishment of the Acushnet Water Board, and for the care and management of the New Bedford Water Works," was passed to be ordained on the 21st day of October, 1869.

This Ordinance establishes the Acushnet Water Board to take the place of the Water Commissioners. The Board consists of five persons: the Mayor and President of the

Common Council being *ex-officiis* members. Of the members chosen at large one retires every year, but the retiring member is eligible to a new election. The Ordinance provides for the continuation in office and authority of the Water Commissioners until the expiration of their term of service, November 30th, 1869. Provision is made for the appointment by the Board, of a Superintendent and Clerk, and all other necessary subordinate officers and agents, who are to hold their situations during its pleasure. The Treasurer of the City is *ex-officio* Water Registrar.

It is not necessary for us to go into the details of this Ordinance. We would, however, give that part of the 16th Section that provides for the appropriation of the Water Rents. It is as follows:

> "The receipts into the Treasury from the Water Rents shall be appropriated as follows:
>
> *First.* To the payment of the expenses of the management and repairs of the Works, and such extension, not exceeding two thousand feet in one year, as may be ordered by the Water Board.
>
> *Second.* To the payment of the interest on the Water Loan.
>
> *Third.* To the payment of the principal of the public debt to an amount not exceeding the amount of the issue of Water Bonds."

These provisions are in accordance with the 13th Section of the Act of the General Court, under the authority of which the Works were constructed. "The City Council shall, from time to time, regulate the price or rent for the use of the Water, *with a view to the payment from the net income and receipts, not only of the semi-annual interest, but ultimately of the principal of said debt so contracted.*"

On the 29th of October, the City Council made choice of William W. Crapo, David B. Kempton and Warren Ladd members at large of the Acushnet Water Board, the first named to serve until June, 1870, the second until June, 1871, and the third until June, 1872. On the 28th day of June, of the present year, William W. Crapo was unanimously chosen for the term of three years.

The last Report of the Water Commissioners is dated November 30th, 1869. We have already given, in the first part of this Report, extracts from this last monthly communication of the Commissioners, in which they set forth the reasons why, at that time, they did not give a full account of the operation which for a period of four years had been under their control. We have no occasion to repeat this part of the Report. In closing they say:

> "Within a few weeks, at the longest, the citizens of New Bedford will receive, as a result of the large expenditure of money in this direction, a supply of water which it is believed will prove ample in quantity and excellent in quality.
>
> The work is so far advanced, that during the month of December it is confidently expected that the water of the Acushnet Lake will flow through the Conduit and will be pumped into the Distributing Reservoir upon Mount Pleasant, and will then flow through the streets where pipes have been laid, available for the extinguishment of fires and for use by our citizens in families and for manufacturing purposes.
>
> At the present date there is but little more work required to accomplish this long desired result.
>
> The expenditures to date have amounted to $526,538.33.
>
> The extent of Distribution Pipe authorized by the City Council, has been laid through the principal streets and where most required for fire purposes.
>
> By a recent Ordinance of the City, creating the Acushnet Water Board, authority is given to the Board to add to this distribution to the extent of two thousand feet each year.
>
> This provision, while it may prove ample hereafter, when the wants of the citizens have been met more fully than they are at present, is not sufficient to meet the present demand for water.
>
> There are several localities where the water is needed and where its supply should not be delayed.
>
> The Commissioners estimate that at least fifteen thousand feet of Distribution Pipe should be placed in the streets early in the ensuing season.
>
> To supply all with water who earnestly desire to use it, more than this extent of pipe will be required. This particular subject should have the attention of the Water Board and of the City Council at an early day."

The Acushnet Water Board was organized on the 4th day of November, 1869. By the terms of the Water Ordinance, the Commissioners were to constitute the Board until the expiration of the time for which they were chosen.

At the meeting of the Board at the above date, William W. Crapo was chosen Chairman.

James B. Congdon was re-appointed Clerk, and was qualified by taking the required oath before William W. Crapo, Justice of the Peace.

At this meeting the kind of service-pipe was fixed upon and a contract consummated for supplying them and laying them down. George A. Briggs, the Acting Engineer, was authorized to act as Superintendent of the Works.

On the 30th day of December, there was a meeting of the Acushnet Water Board as constituted by the Ordinance. The Mayor presided. No business was transacted. Two meetings were held during the month, but no business of importance was presented.

On the 7th day of December, a Commission consisting of James B. Francis of Lowell, Mass., D. M. Greene of Troy, N. Y., Charles H. Haswell, New York, Charles Hermany, Louisville, Ky., J. C. Hoadly, Lawrence, Mass., Joseph Belknap, New York, and George H. Norman, Newport, R. I., met in this City, for the purpose of conducting some experiments with the Pumping-Engine of the Water Works. The invitation was given by William J. McAlpine, Esq., by permission of the City Commissioners. Mr. William Rotch of this City, kindly consented to serve as Clerk, and rendered very laborious and valuable assistance. The Pumping-Engine was designed by Mr. McAlpine, the Consulting Engineer of the Water Works, and he, therefore, as well as the Water Commissioners and the Contractor, were interested in the result of the experiments to be conducted by the examiners. We have no occasion to describe this Engine or to state the result of the experiments. They continued several days, and the results, with a particular description of the Engine, and drawings showing its construction and exemplifying its operations, will be found in the Report prepared by the Chairman of the Committee, J. C. Hoadly, which will make a part of this Report.* It is sufficient for us to state that the result was in the highest degree satisfactory to all who were interested in the Engine or the Works.

At the election in December, George B. Richmond was chosen Mayor; and at the organization of the City Government in January, 1870, Charles M. Pierce, Junior, was chosen President of the Common Council, and these gentlemen, by the terms of the Ordinance, were now members of the Acushnet Water Board, the former its President. The first meeting was held on the 13th of January, and from that date to the present time no monthly meeting has been omitted. In December, 1869, the "Ordinance establishing the Water Rates of the New Bedford Water Works" was passed. It may be observed in relation to the rates thus established that they were agreed upon after a careful examination of the rents charged in other cities, and under the influence of a wish on the part of the members of the Council, to place them as low as it was possible consistently with a due regard for the pecuniary interests of the City and of the provisions of law in relation to the income to be derived from the Works.

The Water Committee for the year 1870, consisted of the Mayor, Aldermen Gifford and Sherman, and Messrs. Mackie, Hitch and Soule of the Common Council.

The operations of the Acushnet Water Board for the year 1870 have been constant, diversified and important; in many cases perplexing and wearisome. Even the records of the Board, extending as they do over *eighty-six* folio pages, give but an imperfect idea of the amount of thought that has been bestowed and the labor that has been performed. Very few, excepting those who have been in some way connected with the enterprise, are aware of the extent and laborious character of its direction and superintendence.

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*In the Appendix will be found some extracts from a "Review of the McAlpine Pumping Machine, by Roswell E. Briggs, Civil Engineer."

The extracts which we have given from the Reports of the Commissioners, continued by them until the expiration of their term of office, have afforded you some insight into the extent and character of their operations. With regard to the labors of the Board, during the year that the work has been under their charge, there are no such sources of information and insight. As we have said, even the records, minute and extensive as they are, fail to give a full impression with regard to the time, labor and thought which have been demanded of those who have been officially in charge of the undertaking.

Although a large proportion of the claims for land taken, and for damages for the right of way for the Conduit had been settled, yet many and some of the most difficult remained.

Damages of an incidental and unexpected character have been presented, demanding much time for their investigation and settlement.

The determination with regard to the streets upon which the Water-Mains were to be laid has taken much time, and has called for the exercise of a careful scrutiny and a sound discretion. Not only in making the contract for the pipe and the excavation, has care and attention been called for, but difficulties connected with this part of our operations have been constantly met with, and have demanded the time, and not unfrequently the patience of the members of the Board.

Questions with regard to the laying down of the Services have been constantly recurring.

The fencing of the Reservoirs and the Engine-Lot, and the operation of clearing up the latter, has called for much attention on the part of the Board, and a large expenditure. Some purchases of land, rendered necessary for the symmetry and convenience of the lot, have been made.

The selection and placing of the hydrants have been an important part of the operations of the year.

Drinking fountains have been obtained and placed in such situations as seemed best calculated to render them useful.

To prevent injury to the banks of the Receiving and Distributing Reservoirs they have been graded and seeded.

In this brief recital we have indicated the variety of operations which have called for and received the attention of the Board for the first year of its existence. It would be impossible in this Report to enter minutely into a description of these operations.

Their nature and extent are expressed in a form to allow them to be pretty clearly understood in the detailed account, which is herewith presented, of the expenditures for the year 1870. In this account all the details are given, and they are arranged under the different heads that the outlay under each may be readily determined.

The whole amount of the expenditure of the year has been $117,840.81, arranged under the following heads:

Conduit,		$6,363.44
Dam,		135.58
Distributing Reservoir,		5,797.54
Distribution,		60,879.57
Whole sum expended,	$68,853.75	
Less received of water takers,	7,974.18	
Engine-House,		4,581.02
Engine,		2,908.48
Running Engine,		3,799.95
Engineering,		2,874.91
Storing Reservoir,		717.98
Receiving Reservoir,		9,431.10
Inspectors,		277.00
Salaries,		2,100.00
Engine-House Lot,		16,055.70
Incidentals,		1,406.54
Peckham Road,		512.00
		$117,840.81

The whole expenditure upon the New Bedford Water Works up to the present time, has been		$641,773.80
To the account as it stands upon the books of the Treasury, there have been added the following items:		
Expense of the preliminary surveys and investigations,	$2,605.34	
Discount upon Bonds sold,	5,000.00	7,605.34
		$649,379.14

The appropriations to this date have been $700,000.00, leaving a balance in the Treasury on the 9th day of December, 1870, of $50,620.86.

The expenditure is arranged as follows:

Conduit,	$170,541.42
Dam,	18,845.24
Distributing Reservoir,	59,591.58
Distribution, including Services,	164,097.50
Engine-House,	32,156.69
Engine,	37,456.33
Running Engine,	3,799.95
Engineering,	23,511.88
Storing Reservoir,	45,556.72
Receiving Reservoir,	26,448.81
Inspectors,	5,570.39
Engine-House Lot,	16,055.70
Salaries,	9,225.00
Incidentals,	7,843.18
Pump-Well and Culvert,	16,561.41
Homestead of Ansel White,	4,000.00
Peckham Road,	512.00
	$641,773.80
Preliminary outlay,	2,605.34
Discount on Water Bonds sold,	5,000.00
Whole amount expended,	$649,379.14

In addition to the detailed account of the expenditures of the present year, the recapitulation of the same, and a summary of the whole expenditure upon the Works, which we lay before you with this Report, we have also had prepared, and now send you, a statement, giving each item of expenditure from the commencement of the enterprise to the present date.

By the 17th Section of the Water Ordinance, it is made the duty of the Superintendent, annually, in the month of December, to make a Report to the Board of the operations in his department.

We have, in the method we have adopted for arranging our Report, had in view the fact, that the statement of the Superintendent would embrace certain parts of our operations and their results, with a definiteness and fullness not to be expected in the general account which it devolved upon us to prepare. His Report, for the reason that to some extent it will embrace the whole period of his connection with the Works, will, for the same reason that makes this a general and not a yearly statement, give you a view of the operation which is not to be obtained from general descriptions or details of expenditure.

His Report will make a part of our own, and to that we would respectfully refer you for such a description of the New Bedford Water Works, as his engineering ability and his intimate acquaintance with all their parts will enable him to prepare.

There are one or two subjects connected with the distribution of the water through the streets, and the Service Pipes by which it is carried into the dwellings and places of business of the inhabitants, which seem to call for attention in this Report.

You have been informed in another part of our Report, that the Commissioners in their arrangements for supplying the Service Pipes allowed to the taker the choice between pipes of lead and those made of iron with a lining of cement.

Nearly all the Services which have been laid have been of one or the other of this description.

Although a large part of the Services have been of lead, yet as there has been, from time to time, and in various forms, controversies upon the subject, the Commissioners feel it to be their duty, as they have allowed lead to be used, and think it to be, upon the whole, the best material that has been or can be used for this purpose, to state the grounds upon which they founded their opinion and their action.

The Board, when the subject first presented itself for consideration, while they were aware of the fact that a belief of the unhealthy character of water passing through leaden pipes was entertained by many, were also familiar with the fact that such pipes had been in use in Great Britian for centuries, and that in all, or nearly all the large cities of this country they were in almost universal use.

Unwilling to rely upon this general fact in a matter of so much importance, the subject was further investigated, and such investigation fully confirmed the impression that had been entertained of the safety attending the use of lead pipes for our Services.

When it became necessary for the Cochituate Water Board to decide the question, as to what kind of pipe should be used for the City of Boston, a careful investigation was entered into, and the result was that lead was unanimously adopted. The Report of the Commissioners on the best material to be adopted for Distributing Water Pipes, covers *sixty-seven* pages. We shall give a few extracts from that interesting and exhaustive publication.

After speaking of the experiments made by Professor Horsford, of Harvard University, they say:

> "These experiments demonstrate that the action of the comparatively pure water of Lakes and Rivers upon bright bars of lead, which, on their immersion in it, is distinctly perceptible, *ceases after a period of a few days; and that this immediate action of the water upon the surface of the lead, forms a coating, which, for all practical purposes, is impervious to water, and entirely insoluble in it.* This coating remains unchanged during any period in which it has thus far been immersed; its appearance after some months or years of immersion, in the case of the Croton, (New York,) is quite the same, as within three or four days from the first immersion."

This protective coating formed upon the surface of the lead pipe by the action of pure water, is a most interesting and important fact in connection with its use, for the purposes of water distribution. It so happens that our short experience in the distribution of the water of the Acushnet, has fully confirmed this statement. A piece of lead pipe laid by us, which we had caused to be taken up that a larger might take its place, was found thus, we may say, beautifully coated. It had been immersed eight months. The interior was as smooth as polished steel. This confirmation of the experiments of the Harvard Professor and the statements of the Cochituate Board was very satisfactory. It is admitted by this Board, that waters of wells and springs in certain situations and under certain conditions may produce an effect upon lead so as to render the water unhealthy. They proceed to say:

> "The negative evidence that no well authenticated cases of disease have occurred, in consequence of drinking the water furnished by the public water-works of the cities of London, Philadelphia, New York, and many other places, where distributed through leaden pipes, authorizes the belief that the scattered cases of disease, which have been usually traced to the use of water from wells and springs, have arisen from some property peculiar to the water from these sources and not common to water derived from lakes and rivers."

The report proceeds to state:

> "Since it has been discovered as the result of repeated trial, that the effect of the Schuylkill and Croton rivers, and of Cochituate and Jamaica Lakes, upon lead, is limited to a short period from its first immersion, and that by this temporary effect, there is invariably produced an indissoluble coating on the surface of the lead, which permanently protects it against any further action of the water upon it, and consequently preserves the water against imbibing any poisonous property; and since it is further ascertained that the more efficient power of discoloring lead, which is found to reside in certain water, apparently pure, *is imparted by a substance rarely if ever found, except in a very minute degree, in the water of lakes and rivers*, there appears to be no longer any good ground to apprehend injurious effects upon water of this discription, from its being transmitted through leaden pipes."

We shall make but one extract more from this Report.

> "Professor Horsford in his report to the Board of July 25th, expresses the

following opinion: "Without an attempt at further enunciation of the conclusions at which I have arrived, I may state, with whatever of emphasis uninterrupted investigation from the first of last February until now, may justly give to the opinion, that *Cochituate water may be served from leaden pipes connected with iron mains without detriment to health.*"

We might, were it necessary, and space would permit, largely multiply our extracts from this Report, all tending to the same result. An interesting feature throughout the testimony *is the formation of an insoluble incrustation, lining the pipes.*

We have before us a publication containing extracts from the report made by the British Government Commissioners, showing the safety and superiority of lead pipes as Water Conduits, from which we propose to make a few brief extracts:

"The water at present supplied in London, may be circulated through leaden pipes, or preserved in leaden cisterns with an unusual degree of safety."

"We are assured by Doyce, the eminent physician of Aberdeen, that during a period of 17 years he has never known an instance of illness from this cause. All the pipes are lead."

"Thomas Dale, Esq., engineer of the Hull Water Works, says that leaden piping which is constantly changed *would become coated very soon, and the lead be protected by the oxide.* I believe that it is quite likely that iron pipes have to be renewed in the course of a few years, from the action of the water upon them."

"Robert Rawlinson, C. B., testified that galvanized iron pipes are not to be recommended."

"Thomas Duncan, engineer of the Liverpool Water Works, stated that he had not found that the water which we now deliver in Liverpool have any effect upon the lead pipes, *as the pipes become coated on the inside by the earthy salts which are held in suspension.* I believe that when the lead is once coated over, the water has no effect whatever upon it."

"Alexander Bain, Esq., Professor at Aberdeen, says that the question of the action of lead upon the water supplied to that city has been a matter of chemical investigation, and the results were perfectly satisfactory."

"Dr. Edward Frankland, F. R. S., remarks: 'We have many cases in those waters which have been examined for the commission, of very soft water not acting in the least upon lead, even upon very bright lead, so that there is no necessary connection between the softness and the action upon lead.'"

"I. F. Bateman, Esq., testified that they use leaden pipes in London; wrought iron pipes will not do; they corrode and burst. He tried iron, but rejected them and substituted lead."

"Samuel Collett Homersham, Civil Engineer, says the water for the supply of Castle Howard is brought half a mile through lead pipe. Speaking of the Catuham Works he says, there we have no complaints, and in fact I may say positively, that there is no action of that water upon lead."

The New York Evening Post of April 18th, 1870, contains a long and able article upon the use of lead for water pipes, with a short quotation from which we shall close what we have to communicate on the subject:

> "Galvanized iron pipe has been extensively used, but it does not meet the requirements of health and durability. Galvanized iron pipe is not suitable for water conduits. Lead pipe has been in use over five hundred years in England and elsewhere, and has, therefore, had a longer practical test than pipe made of any other metal. It combines the necessary requirements of strength, durability, pliability, convenience, cheapness and *health*. The Commission appointed by Parliament some years since, to investigate and report what kinds of pipes were the *healthiest* and best for conveying water, decided in favor of lead."

Thus far in our Report, we have said but little respecting the difficulties we have had to encounter, arising from the failure of contractors to complete their engagements and the necessity of meeting the claims for land taken, and damages in various forms, before the courts. We see no good reason for giving you, in detail, our experience in these respects. The Council and the people are already familiar with the fact that embarrassment and delay, much extra labor and a largely increased outlay have resulted from these sources.

It is gratifying to be able to state, that with regard to the contracts upon the Works, there are but few unsettled questions remaining. We have met most of our difficulties in this part of our operations as they have arisen, and are confident that we can dispose of such as remain without an appeal to any jurisdiction outside of the parties.

It will be remembered that in the communications of the Water Commissioners to the City Council, the fact has been stated, that estimates of the expense arising from land damages could not be presented, because of the disposition on the part of the owners of the land which the exigencies of the work required should be taken, to hold it at prices far in advance of what was considered its real value. To meet this condition of things, not, to be sure, unconsidered in the early movements, but certainly greatly underrated, has required the constant attention of the Board. In the courts and out of them, these questions have been met, and one after another, in one way and another, have been settled. Some are yet unsettled; and with regard to many of them, all that can be said is this, that the same conditions of individual over-estimate and legal uncertainty remain. It should, however, be stated, that these remarks do not apply to all or a majority of the cases where the right of eminent domain has been exercised by the Commissioners under the authority of the General Court, and questions of land damages and other damages have been the result. In a great majority of instances, we have met with a fairness and candor in the demands made, and in the subsequent examinations, highly gratifying, and that have allowed of prompt and satisfactory settlements. We are inclined to the opinion, that notwithstanding the obstacles of this character which have been encountered by us, and the increased trouble and expenditure which have arisen from what we feel bound to consider as unreasonable demands upon the City, we have not in this respect suffered to a greater extent than is shown in the history of all similar undertakings. The difficulties of this character, always encountered, when private property and private rights are surrendered to the claims of public necessity or convenience, are inherent and unavoidable.

Values and injuries are magnified under the influence of excited feeling or the assurance of sympathy from those who in the last resort are to judge between them and the power whose exercise cannot be resisted.

We feel assured that in the exercise of the authority conferred by the law, there has been uniformly manifested on the part of the agents of the City a spirit conciliatory and fair; that under the influence of a strong desire to avoid unpleasant controversy and costly litigation, offers have always been made to the extreme limit in any view of the case allowable; and that every possible effort has been made, when the alternative has been a settlement by the law to secure the rights of the City. It is gratifying to think that by the close of the coming year, the Managing Board will most probably be relieved from this unpleasant part of their duty.

In bringing our Report to a close, it gives us much pleasure to be able to assure you that this expensive and important undertaking has been accomplished in a manner which is to us, and should be to all the citizens of New Bedford, a source of great satisfaction.

This result has been largely owing to the ability and faithfulness of those to whom has been committed the engineering and oversight of the work.

It was fortunate for the City, that at an early stage in the history of the undertaking, those who had charge of it called to their aid some of the best informed minds of the country, and that the Commissioners were able to command the services of one of our ablest engineers when the leading features of the work were to be determined.

William J. McAlpine as the Consulting Engineer, George A. Briggs as Engineer in charge and General Superintendent, assisted by his subordinates, George B. Wheeler, William B. Sherman, Roswell E. Briggs and Israel C. Cornish, gave to the New Bedford Water Works all that was called for of engineering skill and faithfulness. In every stage of the undertaking, the agents of the City in its management, have found on the part of their engineering corps, not only the ability which gave assurance that the plan proposed was the best, but that sense of integrity which secured its faithful execution.

It should follow from this that the plan of the New Bedford Water Works is good, and that, as a whole, the undertaking has been faithfully accomplished.

We would repeat the declaration already made, that the people of New Bedford are this day in possession of a Water Storing and Water Distributing instrumentality, which for completeness of plan, thoroughness of execution, and economy in its outlay, will bear a comparison with any undertaking in this country.

With regard to the expenditure we have but a few remarks to make. It has exceeded the estimates; but this excess has resulted principally from three causes, neither of which are reasons for the belief that what has been said of wisdom in the plan and faithfulness in the execution are not true.

In the first place all the estimates, or rather conjectures, with regard to the expense of the land and other damages, have proved unreliable. Upon this point we have already spoken, and we have nothing to add to what we have said upon the subject.

The giving way of our Storing Reservoir Dam was a most unfortunate occurrence; causing much delay and a greatly increased expenditure. Upon this subject we have only to refer you to that part of our Report which speaks of the event, its causes and consequences.

We have extended the Works much farther than was originally contemplated. Our estimates were for *ten* miles of pipe; we have laid down seventeen miles and a half; and to this large increase of needful and authorized expenditure, is to be added the outlay by which the Engine lot has been enlarged, cleared and neatly fenced, and fences placed around the Receiving and Distributing Reservoirs, and their banks smoothed and seeded.

It should be ever borne in mind, that although when we shall have completed our plans for distribution, we shall have expended upon our Works about the sum of *seven hundred thousand dollars*, and have constructed them entirely on credit, that we have contracted a debt of but *five hundred thousand* for their completion. This is the amount of the Water Bonds issued.

The noble bequests of Sylvia Ann Howland have enabled us to accomplish this. It is true, that upon a moiety of the two hundred thousand dollars which have come to us from this source, and which have met two-sevenths of our whole expenditure, interest is to be paid, as upon the Water Bonds, at the rate of six per centum per annum. But this is a payment that does not impoverish. It is gathered into the Treasury, not to be disbursed to the public creditor, but to foster, under the direction of experienced and devoted public servants, the great interests of public liberal education, and of the diffusion of knowledge among the people.

We are not yet prepared to present to the Council any statements or recommendations with regard to the coming year. Should this be found necessary, a special communication will be addressed to you.

All of which is respectfully submitted.

GEORGE B. RICHMOND,
CHARLES M. PIERCE, JUNIOR,
WILLIAM W. CRAPO,
WARREN LADD,
DAVID B. KEMPTON,
Acushnet. Water Board.

REPORT

OF THE

SUPERINTENDENT

OF THE

NEW BEDFORD WATER WORKS.

REPORT.

City of New Bedford,
Office of Supt. of New Bedford Water Works,
December 6th, 1870.

To the Acushnet Water Board:

Gentlemen,—By the 17th Section of the "Ordinance to provide for the establishment of the Acushnet Water Board, and for the care and management of the New Bedford Water Works," it is provided as follows:

"The Superintendent of the Works shall, sometime during the first week in December, annually, lay before the Board a Report of the general condition of the Works, a detailed statement of all expenditures in his department, and of all such other matters and things in connection therewith as he may deem necessary, or in relation to which he may be specifically instructed by the Board."

In proceeding to discharge the duty which has been placed upon him by the Ordinance, the Superintendent would, in the first place, give his attention to that part of it that is embraced in special instructions from the Board, founded upon the closing provisions of the Section.

The Board having arranged to include in their Report, not only a statement of the proceedings of the year during which they have had charge of the undertaking, but a history of the enterprise from its commencement, the Superintendent and Engineer was directed, in his Report, to give such an account of the leading features of the Works, as would be in harmony with this comprehensive design.

The New Bedford Water Works were projected to supply the City with an abundance of pure water.

Preliminary to the selection of a drainage district, a thorough reconnoissance was made of the country in the vicinity of the City.

These examinations extended to the west as far as the Wautuppa Ponds and to some of the sources from which they derive their supply; on the north to Burns' Brook and Fall Brook in East Freetown, and the Middleborough Ponds situated in Lakeville; and on the east to the valley of the Mattapoisett River and Snippituit Pond; embracing more than one hundred and fifty square miles of territory.

The result of the examination was a conviction that the Acushnet Valley presented the most favorable locality from which the supply could be taken; and subsequent surveys proved the conclusion to have been correct.

After these examinations were concluded, and a survey and estimate had been made for bringing the water of the Acushnet from a point on Benjamin Wilson's farm in the town of Acushnet, it was thought proper by the City Government, in order to have this important point conclusively settled, to have another examination of the territory, and another estimate of the cost.

This work was placed in the hands of Mr. William J. McAlpine, an engineer of great scientific acquirements and large experience.

The following sources of supply had been regarded as possibly available: Long, and Little Quittacus Ponds in Lakeville; Tobey's Pond in the north part of New Bedford; Fresh River at Turner's Mills and Smith's Mills in Dartmouth; Acushnet River at Dogfish Bar, and the Acushnet River in the town of Acushnet at Benjamin Wilson's farm, and at Ansel White's Pond, three-fourths of a mile above Wilson's farm; and the Snippituit Pond in the northerly part of Rochester.

Careful surveys and estimates were made, with regard to all the localities named with the exception of Tobey's Pond.

The Snippituit Pond was regarded only as an auxiliary supply to the Acushnet plan at Wilson's; and the estimated cost of construction and land damages for this purpose was one hundred and twenty thousand dollars.

The estimated cost of the different plans is here given, the cost of distribution not being included.

Acushnet, at Dogfish Bar,	$293,607.50
Acushnet, at Wilson's farm,	395,994.55
Acushnet, at Ansel White's farm,	314,604.55
Long Pond,	366,069.75
Fresh River, at Turner's Mills,	328,572.50
Fresh River, at Smith's Mills,	336,107.50

The sources of Fresh River above Turner's Mills, are in a very level and extensive cedar swamp, covered with a deep vegetable deposit; and the adjoining hill slopes are sandy loam and gravel; a few feet below the surface, the material runs more or less into hard pan.

The impervious nature of many of the hill slopes and the deep vegetable mould in the swamps, would prevent the rain-fall from readily sinking into the strata beneath. Such a water-shed would be likely to give but a small ratio of available water; and as no other district could be added to it at a reasonable cost, no further consideration was given to this plan.

The plan of damming the Acushnet at Dogfish Bar, had some very serious objections. The Reservoir would flow about three hundred acres of land, covered with thick beds of vegetable matter. To cover this large mass of salt marsh with fresh water, would probably revive the decomposition of these extensive deposits of vegetation.

Many acres of the marsh would have only a small depth of water upon them, not sufficient to kill the vegetable growth. This would continue the fermentation for years, if it would cease at all, and thus greatly injure the value of the water for all domestic purposes.

The principal objection to the Smith's Mills plan was the the extensive cedar swamp which would be flowed, and the doubt as to our ability to remove without a very large expenditure, the deep peat and muck deposits.

Long Pond would furnish an abundant supply, present and prospective, of the best quality of water; but as no Legislative authority had been granted to divert any portion of the waters for this purpose no further thought was given to this source of supply, except as a resource in case the Acushnet should fail to yield the requisite quantity.

The Acushnet plan for taking the water from Ansel White's Pond was abandoned, and it was decided to construct the Dam at Wilson's farm. It was found that the superiority of the latter over the former consisted in this, that by the latter the capacity for storage would be greatly increased, and the quality of the water improved. The depth of water would be increased and the vegetable growth diminished.

This location for the Storing Reservoir is the best that could have been made in the Acushnet valley. At this point, thirty-four square miles, or about twenty-two thousand acres of *drainage* area can be made available at some future day, should the growth of the City be such as to require the additional supply.

The water-shed of the Acushnet now tributary to the storage was estimated at thirty-three hundred acres, and the catch-water-drains which could be added, at two thousand more.

The auxiliary supplies from other districts, available if required, are the following:

Snippituit Pond,	1,800 acres.
Catch-Water-Drains,	2,500 "
Little Quittacus Pond,	1,125 "
Long Pond,	11,300 "

Making a total drainage district of twenty-two thousand and twenty-five acres which could be brought to contribute to the future wants of the City.

More than twelve thousand acres of the auxiliary districts could be made available at a cost not exceeding twenty-five thousand dollars, without including the damage to the Mill property below the points where the diversion would be made.

Numerous experiments, embracing many different districts and differing very much in circumstances, have been made in many parts of the Northern and Eastern States, to determine the amount of rain-fall which may be collected and made available. These experiments show, that from forty-five to nearly eighty per cent. (the average being about sixty per cent.,) of the annual rain-fall can be collected.

The average annual rain-fall at New Bedford, for the last fifty years is forty-one and a half inches. This has been ascertained by an examination of a record kept the whole period named, by Samuel Rodman, which I have been kindly allowed to copy. The maximum quantity fell in 1829—fifty-eight and fourteen one-hundredths inches; the minimum in 1846—thirty and sixty-eight one hundredths inches.

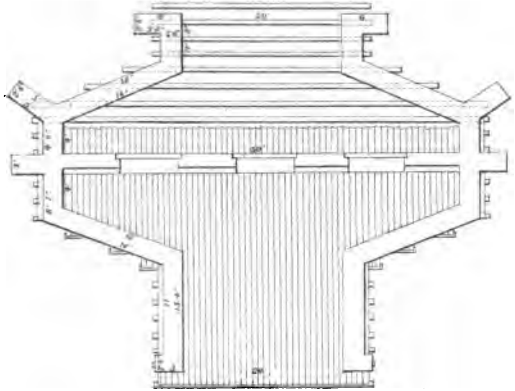
The quantity falling upon the water-sheds of the districts north and east of the City within a circuit of ten miles, cannot materially vary from that stated above.

The following table will show, in a condensed form, all the facts, connected with this interesting and important branch of the subject. It is based upon a population of sixty thousand, and a daily consumption of eighty gallons to each inhabitant:

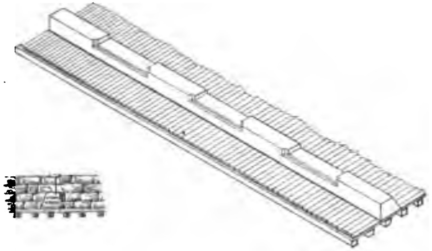
TABULAR STATEMENT OF THE RAIN-FALL, THE AMOUNT OF WATER COLLECTIBLE, THE EVAPORATION, AND THE CONSUMPTION.

Month.	Rain-Fall.	Per cent. Collectible.	Depth Collectible.	Amount Collectible on the Water-Shed.	Depth of Evaporation in Storing Reservoir.	Amount of Evaporation in Storing Reservoir.	Consumption.	Total Evaporation and Consumption.	Surplus.	Deficiency.	Accumulation, or the Required Capacity of Storage.
	Inches.			Gallons.	Inch.	Gallons.	Gallons.	Gallons	Gallons.	Gallons.	Gallons.
January.	3.37	.70	2.36	212,028,300	2	16,335,000	96,000,000	112,335,000	99,693,300		335,935,700
February.	3.26	.80	2.61	234,488,925	1	8,167,500	90,000,000	98,167,500	136,321,425		472,257,125
March.	3.32	.60	2.00	179,685,000	2	16,335,000	102,000,000	118,335,000	61,350,000		533,607,125
April.	3.89	.60	2.33	209,333,025	3	24,502,500	108,000,000	132,502,500	76,830,525		610,437,650
May.	3.65	.50	2.19	196,755,075	5	40,837,500	114,000,000	154,837,500	41,917,575		652,355,225
June.	2.89	.50	1.44	129,373,200	7	57,172,500	120,000,000	177,172,500		47,799,300	604,555,925
July.	2.98	.45	1.34	120,388,950	8	65,340,000	126,000,000	191,340,000		70,951,050	533,604,875
August.	3.86	.45	1.74	156,325,950	8	65,340,000	126,000,000	191,340,000		35,014,050	498,590,825
September.	3.36	.50	1.68	150,935,400	7	57,172,500	120,000,000	177,172,500		26,237,100	472,353,725
October.	3.21	.60	1.93	173,396,025	5	40,837,500	114,000,000	154,837,500	18,558,525		18,558,525
November.	4.02	.60	2.41	216,520,425	4	32,670,000	102,000,000	132,670,000	83,850,425		102,408,950
December.	3.92	.70	2.74	246,168,450	2	16,335,000	96,000,000	112,335,000	133,833,450		236,242,400
Total.	41.73	.58	25.22	2,225,398,725	54	441,045,000	1,314,000,000	1,753,045,000	652,355,225	180,001,500	472,353,725

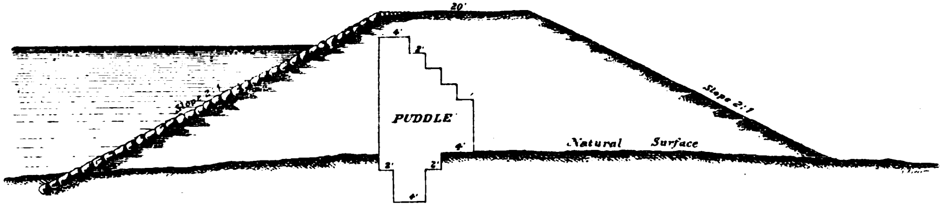
No. 4.



Plan



WASTE WEIR,
East End of Dam



Section of Dam

NEW ENG LITH CO 109 SUMMER ST BOSTON.

STORING RESERVOIR AND DAM.

The Dam which is built to form the impounding Reservoir, and to elevate the waters of the Acushnet to forty feet above mean high tide, is situated in the town of Acushnet, about eight miles north of the mouth of the Acushnet River and seven miles from the City of New Bedford.

The drainage area above the Dam, comprises between three and four thousand acres, and is exceeding well adapted for the collection and storage of a large supply of pure water, in proportion to its area.

The slopes of the water-shed have a very gentle descent; the dividing ridges which separate the waters flowing into this valley from those running to the Mattapoisett, the Fresh, and the Taunton Great Rivers, form a low elevation of country, varying in height from seventy to one hundred and seventy-five feet above tide.

The soil, earth and rock, within the limits of the drainage district is of one and the same general character, derived principally from decomposed and denuded granitic and graywacke rocks; and consist of sandy loam, sand, gravel, and some scattering boulders, in many places underlaid with thick beds of quicksand, forming an excellent filter-bed, separating the water from whatever impurities it may absorb from the surface and imparting little to it in return.

The Reservoir is two and a half miles long and from one-eighth to nearly one-half of a mile in width,—the flowage covering about three hundred acres of land, giving a storage capacity of four hundred millions of gallons of water available above the level which will allow the Conduit to deliver five millions of gallons a day.

The minimum flow of the Acushnet, at the point where the Dam is erected, is about two and a half millions of gallons, and the mean average for the year about five millions of gallons, in twenty-four hours. The lowest stage of water continues only a short time during the dry season, which generally occurs in the month of August.

Whenever during the dryest period of the year, the City may require more water than the minimum flow of the River, it will be necessary to draw from the stored water the deficiency, which is designed to be equal to maintaining the mean average flow of the River for the year, or of supplying a city population of sixty thousand.

The Dam is placed between the banks of the Acushnet, at a point where they are six hundred and fifty feet apart. The west bluff is about fifty, and the east about twenty-five feet above the level of the River bottom.

The site it occupies was overlaid with more or less of alluvial and vegetable deposit, principally muck, varying in depth from a few inches to thirteen feet. Beneath this, was a stratum of hard pan, nearly impervious to water; and this stratum was from one to four feet in thickness. The whole was underlaid by a thick bed of silicious quicksand, extending to the rock formation, and in some places was thirty feet in depth, appearing to pervade the whole country for a considerable distance, in all directions. In the absence of water the sand was hard and compact, and required considerable *picking* before it could be moved.

All the muck was removed from under the base of the Dam, and a trench excavated from six to twelve feet in width, and from five to ten feet in depth, along the middle of the Dam, extending into the banks at each end from fifteen to thirty feet. The trench was filled with a puddle made of gravel, sand and loam, the best material to be obtained in the vicinity, and carried up with the Dam in layers of about six inches in depth, to within three feet of the top, or one foot above the high water line in the Reservior.

The puddle was thoroughly mixed, by cutting and cross cutting with spades; and the finer materials from the excavation were placed upon the upper, and the coarser on the lower side of the puddle wall; and each layer watered sufficiently to keep the whole mass moist, and compact it thoroughly together.

The waste-way for the Reservoir is placed at the east end of the Dam; and is located some seventy-five feet beyond the face of the bluff. A channel was made from the waste leading into the Reservoir about one hundred and fifty feet above the Dam, and below the waste it was carried some two hundred and fifty feet through the bluff to the swamp, and continued through the swamp to the River, a distance of five hundred feet.

The waste is constructed fifty feet in width of rubble hydraulic masonry, except the overfall which is hammer-dressed,—the whole resting upon a timber and plank platform, and that upon a foundation of puddled earth.

The gate-chamber is seventeen by twenty-two feet, and is placed at the west end of the Dam, upon the upper side of the embankment, and is carried out into the Reservoir about fifty feet from the top of the Dam. The chamber is built of hammer-dressed stone, rock-face, laid in hydraulic cement mortar, and carried up to a point four and a half feet above the high water line.

The Gate-House is of brick masonry; the whole resting upon a timber and plank foundation extending three feet beyond the outside of the masonry. The timber is ten inches square, laid two feet from centres, the space between the timbers being filled with concrete masonry. Upon the timber is laid a course of two inch plank, then a thin coat of fine hydraulic mortar, followed by a course of one inch boards, and upon the boards another course of two inch plank, and all spiked to the timber.

On the up-stream side of the timber platform, is placed a row of sheet piling, six feet in depth, made as tight as possible by jointing the edges of the plank and placing them close together, and thoroughly puddling around with fine gravel and loam. Under the platform the puddle is from six to ten feet deep, and is extended several feet outside of it to prevent any percolation which would be likely to occur.

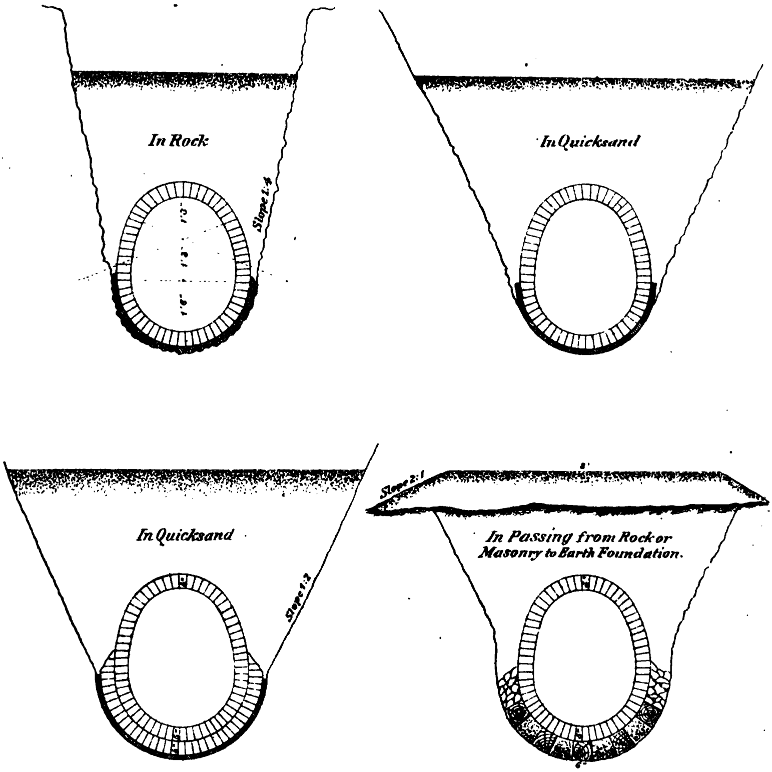
Two belts of masonry, laid in full beds of hydraulic cement mortar, three feet in depth and about two feet wide, are built under the platform, and they are carried over the Conduit to prevent the water from following along the platform and masonry. One of these belts is placed directly under the upper angle of the Dam and the other near the centre.

THE CONDUIT.

The Conduit commences at the Dam, and takes a south-westerly course along the westerly slope of the Acushnet valley, passing over Morse's Brook below the Mills, and winding around the eastern slope of the high ground near the residence of George Parris, and west of a gravel hill on the Wilcox farm, and crossing the Whelden Brook. From thence it proceeds straight to the hill on Alden T. Ball's land near Harrington's Tannery. Here it turns to the left, passing through the Tannery Pond, crossing the Tarkiln-Hill road, and in front, and near the residence of Daniel Ricketson, cutting through the ledge of rocks to the south of his premises, and crossing Acushnet avenue. Thence bearing more to the south-east, it passes east of the rock bluff on the Hannah Bates land. Here its course tends to the west, crossing the Belleville road about eight hundred feet west of Belleville wharf, and continues south-westerly, crossing the Acushnet avenue again near the residence of the late Willard Nye, and terminating on the Coggeshall farm at the Receiving Reservoir, five and five hundred and seventy-four one thousandths miles from the Dam.

Geologically, the formation of the country through which the Conduit passes is similar to that of the drainage area already described. For a mile and a half to Morse's Mills,

No. 3.



SECTIONS OF CONDUIT.

New Eng. Lith. Co. 104 Summer St. Boston

the excavation was almost wholly through sandy loam, sand and gravel, and a few spurs of the granitic rocks.

The next mile and a half, from the Mills to the Head-of-the-River road on the Terry farm, it passes through a section principally of low wet lands; beneath the soil a hard pan stratum of several feet in depth, generally prevailed, and under it a bed of quicksand, which was encountered for more than half of the distance. This sand in many places was very loose and difficult of excavation.

From the Terry farm to Harrington's Tannery, the excavation was through a gravel plain, with the exception of the cut in the hill on Mr. Ball's land, where another of those difficult strata of quicksand was encountered. After crossing the Tannery Pond, the quicksand bed was again met with in the bottom of the trench, and continued for two thousand feet. Beyond this, to the Receiving Reservoir, the earth excavation was generally through a harder and more compact gravel, in many instances running into hard pan.

About two thousand feet of this distance the bottom of the trench was more or less through a quicksand, and large quantities of water were encountered.

The construction of this part of the Water Works was attended with much difficulty. Although no excavation was over twenty and a half feet in depth, and no rock-cutting more than fifteen feet, and although there were only three points on the route where the grade line or bottom of the Conduit is above the surface of the ground, yet the magnitude of the work, and the character of the country through which the Conduit passes, rendered the undertaking one requiring great care, and the constant exercise of the skill and attention of those by whom it was directed.

In excavating the trench for the Conduit, the slopes were generally made one foot horizontal to four feet vertical, and of sufficient breadth at the surface to give four feet in width, two feet above the grade-line of the Conduit.

The earth below this level was excavated to correspond with the curve of the extrados of the lower arch.

Where quicksand occurred, the slopes were flattened or sheet-piling was used, to prevent the sand from running into the trench.

Nearly a mile in length was piled to save excavation and expedite the work. Many of these sands were quite troublesome, causing a good deal of delay in the construction, on account of the large quantity of water intermixed with them, keeping the whole mass in a semi-fluid state, and thereby making it necessary to keep constantly bailing and pumping, to enable the work to proceed.

The bottom of the rock excavation was made to conform as near as practicable to the outside of the brick work, to a height two feet above grade line; and above this point the slopes on the sides were made one foot horizontal to five feet vertical.

Wherever an embankment was required to be raised along the line of the Conduit to support the work, the roots and stumps were grubbed up and the vegetable matter removed from under it. The earth forming the embankment was kept free from large stones, roots and perishable material, and was carted on with teams in layers of about six inches in depth, and moistened with water whenever required to comcompact it together.

Very little puddle embankment was necessary; and only two or three places on the line were required to be made of puddled earth.

The Conduit is built in the form of an egg-shaped oval, the horizontal interior diameter being three, and the vertical, four feet.

The thickness of the arches, where no foundation was required, is generally five inches, the width of a single brick. The brick used were hard burned, made to a pattern, nine inches long, five inches wide, and about two and a half inches in thickness; the beds and builds parallel with the line of radius of the arch.

The lower arch is a semi-circle of three feet, the sides four and a half feet, and the top arch one and a quarter feet interior diameter.

Where no foundation was required for the lower arch, the the brick were laid in a bed of cement mortar, one inch thick, the mortar filling all the irregularities made in excavation.

The mortar used was generally composed of one part of hydraulic cement and two parts of sand.

The brick were laid in a full bed of the mortar, and the outside of the top and side arches were plastered over with a coat, one-half inch in thickness, connecting with the outside bed of mortar of the lower arch.

Through the quicksand formations, a plank foundation was put in, the plank varying in width from six to eight inches, and were from ten to fifteen feet in length.

The plank were put in place in short sections; and when in position they were covered with a thick bed of mortar as described for the lower arch where no foundation was necessary.

Constant bailing and pumping kept the water and sand out until the arch was laid and the Conduit completed, and the earth back-filled to the top of the upper arch.

The most difficult bed of quicksand was encountered near the Dam. Through this a double ring of brick was laid upon a plank foundation in the same manner as described above.

Where the Conduit passes from a foundation of masonry, as over the top of a culvert, to an earth support, timber from fifteen to eighteen feet in length, were put in the bottom of the trench, one end resting upon the masonry and the remainder of its length on the earth.

These timbers were put in to distribute more equally the weight of the Conduit over a greater length of space, and prevent it from settling and breaking off between the earth and masonry support.

In all cases where a highway is crossed, a double ring of brick-work is extended from the springing line of the inverted arch over the top of the Conduit.

Thirteen culverts and two over-ways have been built on the line. No streams of any considerable size are crossed, and only three culverts required having a water-way of more than eight feet area. At Morse's Mills and at Harrington's Tannery arch culverts are constructed.

That at Morse's Mills is built partly on a ledge and partly on a foundation of heavy slabs of granite paving laid in a bed of cement mortar, and has a span of nine, and a rise of five feet. That at Harrington's Tannery rests upon a timber and plank platform, and has a width of eight, and a height of four feet. These are segmental arch culverts, having a bench or abutment wall of fifteen inches in height.

The end voussoirs, the steps to the wing walls, and the coping-stones, are of hammer-dressed masonry with rock face, the remainder of rubble-work, and the whole are laid in a full bed of hydraulic cement mortar.

Three waste-weirs, for the discharge of any surplus water which may be permitted to enter the Conduit, are built along the line.

They are constructed to prevent any pressure against the masonry of the Conduit from the interior.

The over-flows are regulated by stop plank, and are so arranged that the full capacity of the Conduit may be made available, or any portion thereof which may be desired, without allowing any waste of water.

The waste-weir having the largest capacity is located near the Dam, and is connected with a chamber, seven and a half feet in height, seven feet in width, and eight feet long. The over-flow is discharged into a culvert which conducts the water to the stream below.

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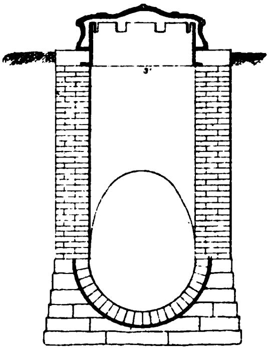
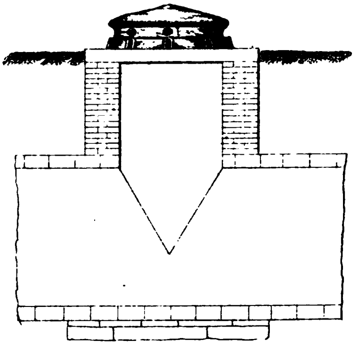
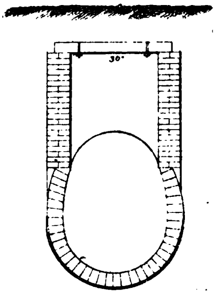


Vertical Section



Longitudinal Section



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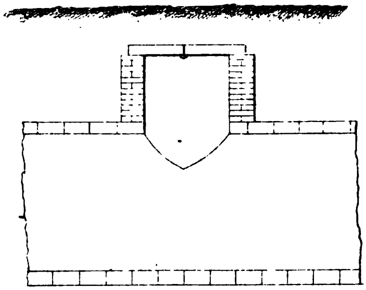

Longitudinal Section

VENTILATORS.
AND
MAN HOLES.

[illegible]

From the Waste-Chamber to the Gate-Chamber at the Reservoir, a distance of one hundred and seventy feet, the Conduit is enlarged, so that it may be used for a waste-culvert to the Reservoir.

The waste-weirs at Morse's Mills and at Harrington's Tannery, are constructed upon the top of the arch culverts. The over-flow passes through a hole in the top of the arch and drops into the streams below.

This arrangement saved the expense of building a waste-culvert to lead the waste water a sufficient distance from the work to prevent injury.

Five ventilators are built along the line, for the free circulation of air through the Conduit. They are cylindrical, having an interior diameter of three feet, are groined into the top and side arches of the Conduit, carried up to the surface of the ground and coped with a cast-iron cylinder which has a flange upon its side resting upon the top of the masonry. The cylinder projects about nine inches above the surface. This is covered with a cast-iron cap somewhat larger than the inside cylinder, made in an ornamental form.

On the sides of the caps at the bottom and under the moulding near the top, holes are made for the circulation of air. At Morse's Mills and at Harrington's Tannery, upon the top of the waste-weir chambers, a ventilator is placed of the above description.

To admit of ready access to the interior, twenty-two man-holes are built along the line. The holes are circular, have an interior diameter of thirty inches, are groined into the top arch of the Conduit and carried up to within one foot of the surface of the ground and covered with a large flag stone.

RECEIVING RESERVOIR.

The Receiving Reservoir is situated on the south side of Coggeshall Street, east of, and adjoining the New Bedford and Taunton Railroad.

The embankment forming the Reservoir is fifteen feet wide on the top, with slopes on the outside of two horizontal, to one perpendicular; and on the inside one and one-half horizontal to one vertical.

The inside slope has a lining of puddled earth, four feet in width at top-water line, and ten feet wide at the bottom of the Reservoir, and carried down three feet in width, three feet below it.

All the soil, roots and other perishable materials were removed from the site of the Reservoir and from under the embankment, and the most impervious portion of the material was selected and used for the puddled lining of the interior slope.

The front portion of the embankment next the puddled lining, is made of the best and most impervious material remaining after the selection for the puddle had been made; and the less impervious was put into the outside slope.

The earth was carted on with teams, in layers of about six inches in thickness, and wet so as thoroughly to compact it together.

Upon the inside slope is placed a lining of granite stone, one foot thick, having the joints filled with fine gravel.

The Reservoir has a depth of twelve feet when filled to high water line, and a capacity of three million gallons.

At opposite corners of the Reservoir, a small Gate-House is placed, similar to that described at the Storing Reservoir. One is used as an influent chamber, into which the Conduit discharges; and the other as an effluent chamber, connecting with the culvert leading to the Pump-Well and with the waste-drain of the Reservoir.

Between the Receiving Reservoir and the Pump-Well, a distance of two hundred and seventy feet, a rubble-stone arch is built to conduct the water to the Pumps.

A small stream which supplies the Wamsutta Mills and the Copper Works, was to be carried over the top of the culvert.

To do this, without damming the Brook, the bottom of the culvert had to be placed two feet below the bottom of the Reservoir. This would allow the arch-stone to be fifteen inches in depth where the Brook would cross it.

When the Reservoir was full, the interior of the culvert, at the crown of the arch, would have a vertical pressure equal to ten feet head of water, or six hundred and twenty-five pounds to the square foot, while the arch-stone would weigh about two hundred and twelve pounds to the foot, if they should be made fifteen inches in depth. About twenty-five feet of the culvert had an earth covering of only two feet over the top; this would increase the weight to about four hundred pounds to the square foot. The remaining portion of the arch had from four to ten feet of earth over it.

To counteract the lifting force, prevent percolation, and distribute the pressure over as large an area as possible at a reasonable cost, was the object to be accomplished.

The plan adopted was to line the interior of the arch with pine plank, and load the crown of the arch with an additional weight of stone. The plank used were thoroughly seasoned, three inches thick, and from five to five and a half inches in width, milled to a uniform thickness, and the edges made straight and beveled on a line parallel with the radius of the arch.

In the centre of the edges of the plank, a groove, five-eighths of an inch in width, and three-fourths of an inch in depth, was cut, into which a tongue was fitted that filled the groove.

The plank were placed directly upon the centering of the arch; and as they were put together, the tongues were placed in the grooves, and a thick bed of cement mortar was spread over the outside of the plank previous to placing the ring-stone in position, which filled all irregularities of surface upon the face of the stone.

The plank lining accomplished all that was anticipated, and no leak has yet appeared.

The radius of the culvert is three feet and the abutment walls one foot, in height. It is placed upon a timber and plank foundation. Two courses of plank were used in the foundation; the upper course being laid so as to cover joints of the lower, and all were thoroughly spiked to the timber.

THE PUMP-WELL AND ENGINE-HOUSE.

The Pump-Well and Engine-House are situated on the west side of the New Bedford and Taunton Railroad, west of Purchase street.

The Pump-Well is seventeen feet in depth, thirty-one feet long, and twelve feet wide, with four recesses, five by six feet for the Pumps.

The Pump-Well walls and the foundation for the Engine, rest upon a rock foundation, and are built of large blocks of granite, which have hammer-dressed beds, builds and joints. They are laid in courses, in full beds of hydraulic cement mortar and all thoroughly bonded together.

DISTRIBUTING RESERVOIR.

The Distributing Reservoir is situated on Acushnet Heights, between Mount Pleasant Street and the Hathaway Road, and covers five acres of land. The earthern embankment which forms the Reservoir, is from eight to eighteen feet in height above the natural surface of the ground, is fifteen feet in width at the top, with slopes inside and outside, of two feet horizontal to one vertical.

The turf, roots, and all perishable material were removed from the site. The inside slope of the embankment is lined with puddled earth, seven feet in width, one foot above high water line in the Reservoir, and fifteen feet in width at the bottom. Below the bottom of the Reservoir a trench was excavated in steps, five feet in depth and filled with puddled earth.

The puddled lining was made from the most impervious portions of the excavation, mixed with from twenty-five to thirty per cent of loam in bulk, and carted upon the embankment in layers of about six inches in depth, and wet so as to moisten the whole mass, then cut and cross cut with spades to make it thoroughly compact.

The embankment next to the puddled lining, is formed from the best material remaining after the puddle had been selected. The more porous portion of the material was put in the outside angle of the bank and the soil upon the outside slope.

The earth was carted on with teams in layers of about six inches in thickness and wet when necessary. The larger stone brought out in the carts were put in the outside of the bank, care being taken to have them so placed that no hollow spaces between the stone should be left vacant.

Upon the inside of the embankment, a slope of large sized, well shaped, quarried stone is laid, eighteen inches thick at the bottom and twelve inches at the top, two feet above high water line. The edges of the stones were broken to a fair line, and the joints between them filled with gravel. Between the back of the stone facing and the front of the puddle, is placed a layer of nearly one foot in thickness, of small stone and gravel, which was raked and thrown from the puddle lining upon the slope.

The bottom of the Reservoir is of an impervious nature; and to level it was all that was deemed necessary.

Soon after the Reservoir was filled, a small amount of percolation showed itself at the the south-west and north-east sides. That at the south-west side came to the surface of the ground a short distance from the embankment, giving indication that it passed under the puddled lining below the bottom of the Reservoir.

At the north-east side, a slight sweating made its appearance near the foot of the slope, which appeared to have passed through the embankment. These percolations were carefully watched; and it was soon discovered that the water was gradually diminishing. It has continued to diminish. Little, if any, is now to be seen at the north-east side, and but an unimportant quantity shows itself at the south-west part of the Reservoir. The Reservoir, when filled to high water line has a depth of seventeen feet, and a water surface of three and one-eighth acres. It will contain fourteen millions of gallons.

The Gate-Chamber is placed on the east side of the Reservoir, at the foot of the inside slope. It is built of rubble granite, laid in courses, in full beds of hydraulic cement mortar.

It is divided into three divisions; the Force-Main, Drain-Pipe and Gates occupy one division; the gates regulating the delivery into the distribution are placed in the Receiving Well; and in the delivery-chambers are the screens and two sixteen-inch Distribution Mains.

Over the chamber is built a substantial brick Gate-House, which is connected with the top of the embankment by a foot-bridge.

ENGINE-HOUSE.

The Engine-House is thirty-eight by fifty feet, and the wing in which the boilers are placed is thirty-two feet eight inches by thirty-nine feet eight inches. It is built of granite masonry, the base of rough ashlar laid in regular courses, and the buttresses, cornices, arches over the doors and windows and pilasters are of stone cut to a pattern. The body of the building is of small rubble-stone, of irregular shape, the whole being laid in full beds of mortar, made of one cask of hydraulic cement to one of common lime, mixed with a sufficient quantity of clear, sharp sand. The roofs are covered with slate and are supported by iron trusses.

The lot on which the Engine-House stands, is bounded on all sides by streets, and is about five hundred feet in length by four hundred feet in width; and when it shall be tastefully laid out will present a pleasant appearance.

The building was designed by our former townsman, Edward D. Lindsey, of New York, and does much credit to his taste and skill as a professional architect. It is a convenient and substantial structure, and its style and graceful proportions give it an attractive appearance.

THE PUMPING-ENGINE.

The Pumping-Engine is a vertical beam, condensing, expansive steam-engine, with two vertical single-acting pumps; one of which is placed on each side of the beam-centre.

The Engine was designed by William J. McAlpine of New York, Consulting Engineer of the Works, and is called the McALPINE PUMPING MACHINE. It was constructed by George W. Quintard of the Morgan Iron Works of New York.

It was guaranteed for two years from the time of its acceptance, and to show a duty at the trial test, of sixty millions pounds of water raised one foot high by one hundred pounds of good anthracite coal.

A more definite description of this Engine and its action is not here required. The Report of the Board of Examiners, by which it was fully examined and tested, which has been printed and illustrated under your direction, contains a carefully prepared description of the machine and its working. Permit me to express the hope that you will allow it to be connected with your Report.

I would here state that the Engine continues to accomplish all that was claimed for it by the designer; and it is believed that a better duty could now be shown, should the machine be put to a test, than was obtained at the time of the trial.

This machine, that it may continue in its performance to meet the conditions of the contract and the results of its trial under the best engineering ability of the country, must have given to it the constant supervision and ability of a competent engineer.

Mr. Charles B. Smith, who has always had it in charge, is well qualified for his position; and no want of faithfulness on his part has prevented our Engine from fully meeting the expectation of those most interested in its performance.

THE FORCE-MAIN.

The Force-Main, leading from the pumps to the Distributing Reservoir, is of cast-iron, sixteen inches in diameter and nineteen hundred and ten feet in length, measuring to the west side of the effluent chamber. From this point, to the west side of the Reservoir, a distance of three hundred feet, the water is conducted through a cement pipe, and discharged at the bottom of the Reservoir upon a pavement laid in cement mortar. The Main starts at the pumps, at a level of thirty-five and one-third feet above tide water, and delivers the water at the bottom of the Reservoir at an elevation of one hundred and thirty-seven and a half feet above tide.

In this arrangement, the head of water is constantly varying with the depth in the Reservoir; but no waste of power takes place, as is the case where the water is pumped into an influent chamber and allowed to flow over a weir into the Reservoir.

Near the Engine-House and above the Check-Valve on the Force-Main, a connection is made with a ten-inch auxiliary Force-Main, which is laid through Purchase Street to Pearl Street, a distance of about four thousand feet.

This auxiliary pipe was designed to be used for the double purpose of a pump and Distribution Main.

In the Report upon the Pumping-Engine by the Committee of Engineers, this arrangement is fully examined; and the

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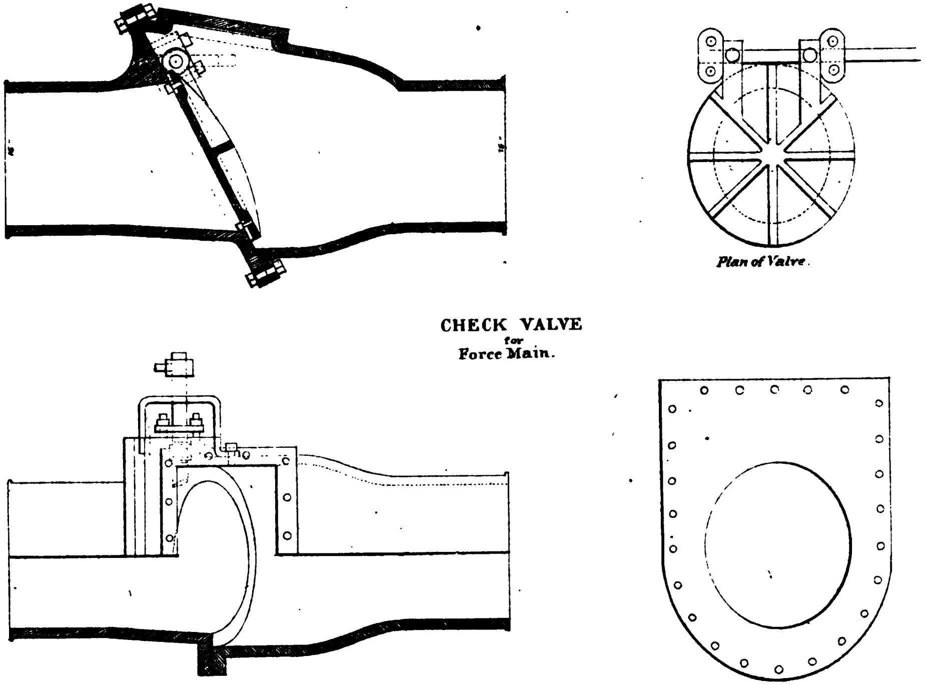

CHECK VALVE
for
Force Main.

Plan of Valve.

Flange & Valve Seat.

New Eng Lith Co 109 Summer St. Boston.

use of a sixteen-inch Rising-Main and of this ten-inch auxiliary is pronounced under the circumstances, to be judicious. Some doubt has been thrown upon the propriety of this conclusion in its fullest extent by the fact, that the multiplication of the Service Pipes has caused such fluctuations in the pressure on the Mains as at times to interfere with the efficient working of the Engine, although these fluctuations did not exceed two and a half pounds pressure per inch. As, under ordinary circumstances, it is not important that this ten-inch auxiliary Force-Main should be open when the pumps are in motion, the gate in it has been closed, and all the water forced into the Distributing Reservoir.

DISTRIBUTING MAINS.

Previous to making a contract for the Distributing Mains, a careful examination was made as to the relative value of cast-iron, and wrought-iron cement lined pipe.

Taking the tests which have been applied to cast-iron, and to wrought-iron cylinders riveted together with a single line of rivets, and giving to the latter the advantage of the trifling strength of the cement lining, the result was nearly five to one in favor of the cast-iron. It was however shown, that the wrought-iron cement pipes had stood and would no doubt stand, any amount of pressure likely to be brought upon them, including the concussion to which they would be liable by any carelessness in filling when they might be emptied for making connections or repair, or by suddenly closing several hydrants which had been drawing heavily upon the Mains.

After a careful consideration of the subject it was decided to receive proposals for both. It having been ascertained that the wrought-iron cement pipe could be obtained about twenty per cent. lower than the other, the preference was given to it for all Mains excepting the ten and sixteen-inch Force-Mains and the Mains on Water Street.

The system and size of the pipes were arranged by the

Consulting Engineer. The extent of each size laid is as follows:

Force-Main Cast-Iron Pipes.	
16 Inch,	2,207 feet.
12 "	28 "
10 "	4,096 "
Wrought-Iron Cement Pipes.	
12 Inch,	6,179 feet.
10 "	5,721 "
8 "	7,544 "
6 "	9,511 "
4 "	22,234 "
Cast-Iron Pipes.	
6 Inch,	5,671 feet.

FIRE-HYDRANTS.

In arranging the plan of Fire-Hydrants, an examination of those in use in other cities, showed the inadequacy of the style of such as are in general use to supply a steam fire-engine to its full capacity. These Hydrants have a bore of only two and a half to three and a half inches in diameter, and a nozzle from two to two and a half inches. They are connected with the Street Mains by pipes of from three to four inches bore, and from ten to thirty feet in length.

The Hydrant we have adopted is known as the Flush Hydrant. It has twelve and a half square inches of water-way, and a frictional surface of the same area, with a four-inch delivery nozzle, being connected with the Mains by a pipe about six and a half feet in length and four inches in diameter.

Some of our Hydrants are made with double nozzles. These have a Y branch upon the upper end of a six-inch upright pipe, and are connected with the Street Main by a six-inch pipe.

This class of Hydrants is placed on the large Mains only, and in districts which require extra provisions for the extinguishment of fires. They have a water-way of twenty-eight and one-quarter, and a frictional surface of twenty-two inches.

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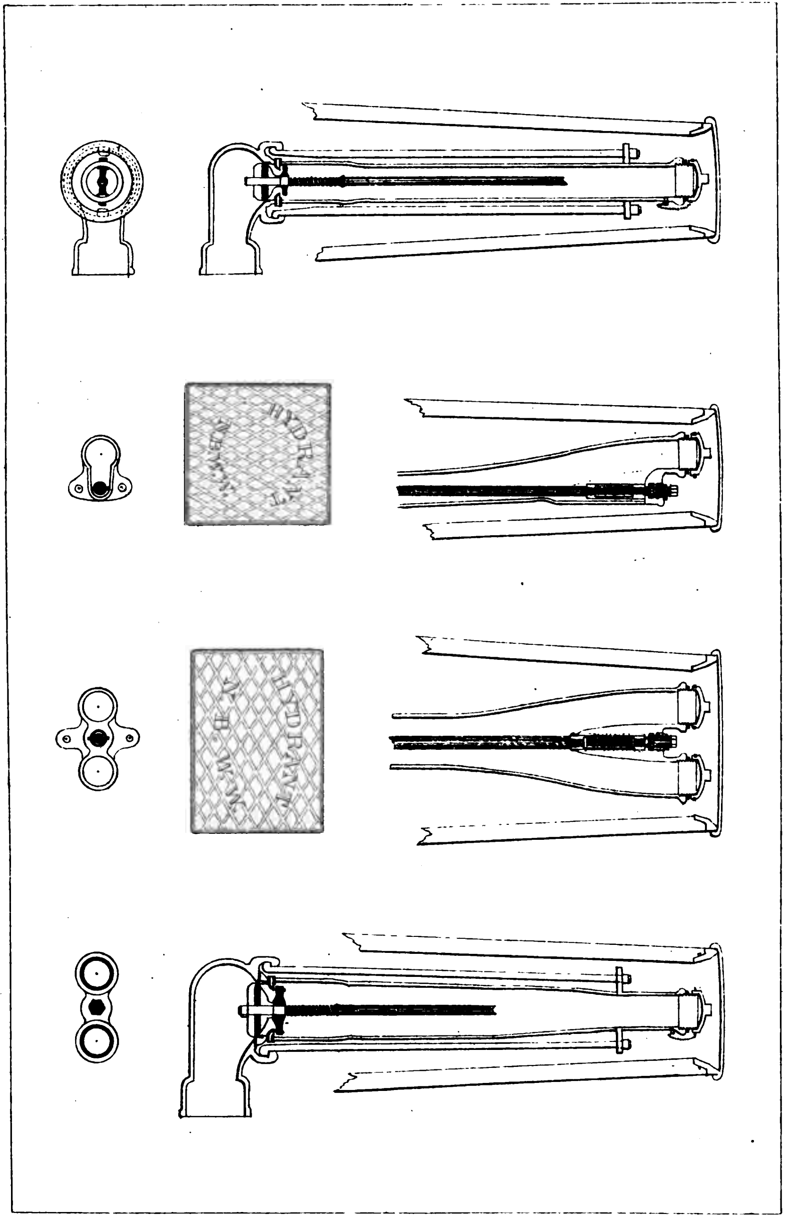


NEW ENG LITH. CO 109 SUMMER ST. BOSTON.

Our Hydrants are placed from two hundred and fifty to five hundred feet apart, according to locality. In cities compactly built the usual distance is about three hundred feet. When the water was let into the mains, (November 24, 1869,) ninety Fire-Hydrants had been connected with the Distribution Pipes.

STOP-GATES.

Stop-Gates, for regulating the flow of water through the pipes, are important parts of the Distribution arrangements. Their construction and placing require much attention. They must be so arranged along the lines of the Mains as to allow the repairs and extensions to be made with economy and prevent subsequent alterations.

The Gates are all boxed, and are fitted with heavy cast-iron frames and covers, large enough for convenient entrance. Fifty-eight Gates have been placed upon the Mains, averaging five and a half per mile.

MISCELLANEOUS.

The extent of the work peformed in the construction of the New Bedford Water Works, cannot be accurately given. This is owing to the fact that a portion of it was performed on a *lump-contract*. No very accurate measurements were taken of that part of the work.

The quantity will not, however, materially vary from what is shown in the following statement:

Earth excavation,	186,817	cubic	yards.
Puddle Bank,	25,577	"	"
Rock Excavation,	5,384	"	"
Stone Masonry of all kinds,	9,295	"	"
Brick Masonry of all kinds,	7,052	"	"
Timber and Plank in foundation,	200,000 feet, board measure.		

The original estimate for the cost of the New Bedford Water Works was five hundred thousand dollars.

Mr. McAlpine, the Consulting Engineer, after making a thorough re-examination of the territory, and having the advantage of additional surveys, estimated the expense of the work, including ten miles of Distribution pipe at five hundred and fourteen thousand dollars. With twenty miles of Distributing Mains, his estimate was six hundred and four thousand six hundred and thirty-four dollars.

The Works complete, with eleven miles of pipes, cost about five hundred and twenty-six thousand dollars.

The following are the names of the original contractors:

Clearing the Storing Reservoir, Benjamin Wilson, of Acushnet.

Raising the Ansel White Dam and the Road which passes over it, Ansel C. White, of Acushnet.

Storing Reservoir Dam, George W. Lobdell, of Mattapoisett.

Conduit and Receiving Reservoir, Daniel Cram & Son, of East Boston.

Culvert leading from the Receiving Reservoir to the Pump-Well, the Pump-Well, and the foundations for the Engine-House, to Appleton, Crane & Lynch, of Boston.

Distributing Reservoir, to Appleton, Crane & Lynch.

The Contractors for the Engine-House were as follows: The masonry to Sawyer and Howland, and the wood work, to Jenney, Bates and Brownell, of New Bedford.

Distribution Mains, to George H. Norman, of Newport.

Daniel Cram & Son, after working a portion of one season, assigned their contract to E. H. Wakefield, of Boston.

Mr. Wakefield continued the work for a year, during which time he constructed about seven-eighths of a mile of the Conduit, the large culvert at Morse's Mills, several smaller culverts and the greater portion of the Receiving Reservoir.

At the end of the year, Mr. Wakefield also gave up his contract, and the work was completed by George H. Norman, of Newport.

Messrs. Appleton & Co. completed the Culvert, Pump-Well, Engine-House foundations, about one-half of the earth work for the Distributing Reservoir, and a small portion of the slope-wall. They then gave up their contract.

The work for the completion of the Distributing Reservoir was re-let to George W. Lobdell, who finished it according to the stipulation.

For convenience of supervision, Assistant Engineer George B. Wheeler was placed in charge of the Conduit, and William B. Sherman, of the Receiving Reservoir, Culvert, Pump-Well, Engine and Engine-House foundations and the Distributing Reservoir.

Mr. Sherman resigned, September 1, 1868, and his place was supplied by Roswell E. Briggs, Civil Engineer, who had been more or less connected with the work from the commencement.

Israel C. Cornish, had charge of the Distribution Pipes.

The inspectors of masonry were Jeremiah Lewis, William Ingalls and John A. Lee, who performed their difficult duties in a judicious and faithful manner.

The plans and maps, giving the details of the different structures were prepared by Assistants Sherman, Briggs and Cornish. They were, for accuracy and style of finish, all that could be desired.

I feel under very great obligations to Mr. McAlpine, your Consulting Engineer, for the courtesy which marked all his intercourse with me, and the ability with which he discharged his duties.

Since the introduction of the Acushnet water, the principal improvements made upon the Works have been the trimming and seeding of the slopes of the Reservoir banks; clearing the Receiving Reservoir and Engine-House lots; building a fence around the Receiving and Distributing Reservoirs and on three sides of the Engine-House lot; and laying twenty-eight thousand four hundred and eighty-nine feet of Street Mains and about five hundred Service Pipes.

STORING RESERVOIR.

During the past year the water in the Storing Reservoir has been kept nearly to high-water line.

In June the water was drawn down about sixteen inches below the height which the City has a right to flow. This was done to accommodate the mill owners on the stream below.

At this time the drought had commenced, and it continued for some months; making it impossible to fill the Reservoir until towards the end of September.

Had you refused to supply the mills in June, a full Reservoir could have been maintained, although a larger quantity than was freely distributed to the citizens, would have run to waste.

DAM.

The Dam at the Storing Reservoir has required no repairs during the year; and the small amount of *seepage* which showed itself at the foot of the slope near the east end, has considerably diminished and gives every indication that the silting-up process, will, in the course of a year or two, stop all percolation there or under the bottom.

CONDUIT.

The embankments along the line of the Conduit have been trimmed by filling the gullies on the slopes.

Where they were left, without being filled to the stipulated lines, they have been raised and widened and are now in good condition.

In November, the water was let out of the Conduit, and Mr. John A. Lee, who had been connected with the work as an inspector, was employed to go through it, make a thorough examination of its interior, and remove all obstructions which might be found.

I learn from his Report, which I have before me, that on the 9th day of November last, he commenced his examination at the ventilator on the land of Benjamin White, and that he traversed the whole length of the Conduit, carefully noting its condition, and removing all the accumulations found in it.

That the examination might be wholly reliable, Mr. Lee then reversed his course, and traversed the Conduit from the Gate-House at the Receiving Reservoir to the Dam at the Storing Reservoir.

The accumulations which were found in some portions of the Conduit, and which the inspector caused to be removed, were mostly such as washed in at the time of the construction, or which entered through the man-holes before the covers were placed upon them.

His statements with regard to the condition of the Conduit, are applied to different portions of it, but the whole may be summed up in the following remarks:—that the Conduit is generally sound, and in good condition except a "roughness" which is found in about two-thirds of its length;—that for about one hundred and fifty feet in a portion named, "the mortar was out of the joints above the springing line of the inverted arch, the lower arch being all sound." He thinks this was caused by the frost at the time of construction.

During the coming season a small amount of labor will suffice to keep the embankment in order.

RECEIVING AND DISTRIBUTING RESERVOIRS.

The banks of these Reservoirs are in excellent condition. The slopes of the embankments will require some care, and where the grass seed did not take well, it must be renewed.

PUMPING-ENGINE.

I here lay before you a tabulated statement of the amount of work performed by the McAlpine Pumping Machine.

It will be seen that the average duty for the year has equalled 58,429,365 foot pounds, raised one foot high with one hundred pounds of coal.

If the incombustible material in the coal had been deducted, fourteen per cent. would have been added to the duty as stated.

TABULATED STATEMENT OF WORK DONE BY THE McALPINE ENGINE AT THE NEW BEDFORD WATER WORKS.

1870.	No. of Days Pumping.	Total Time Pumping.		No. of Revolutions of Engine per Month.	Average No. of Revolutions.	Coal Consumed.			Water Pumped.	Pounds pressure of Steam per Square Inch.	Pounds Pressure of Water per Square In.	Cut Off.	Oil.	Average Monthly Duty in Pounds raised one foot high by 100 pounds of Coal.
						Raising Steam.	Pumping.	Total.						
Month.	Days.	H.	M.	Revolutions.	PerMin.	Pounds.	Pounds.	Pounds.	Gallons.	Boilers.	Pumps.		Gal.	Duty.
January.	1	9	20	6,350	11.33	1,500	3,900	5,400	1,873,250	24	57	4-10	3-8	53,385,986
February.	2	21	45	14,808	11.34	2,000	8,850	10,850	4,368,360	24	58 1-2	4-10	5-8	56,246,990
March.	3	28	35	19,830	11.56	2,500	10,475	12,975	5,849,850	24	58 1-2	4-10	5-8	62,590,696
April.	3	33	10	23,408	11.76	3,000	14,200	17,200	8,905,360	24	58 1-6	4-10	1 1-8	55,111,884
May.	4	33	55	23,656	11.62	2,525	13,400	15,925	8,978,520	24	58	4-10	1 3-8	58,986,300
June.	3	33	30	23,598	11.74	2,500	14,200	16,700	8,961,410	24	58	4-10	1	55,409,261
July.	4	45	40	31,558	11.51	4,100	18,000	22,100	9,209,610	24	58 1-2	4-10	1 5-8	58,945,803
August.	9	89	05	59,852	11.21	7,300	36,100	43,400	17,656,340	24 1-3	58 1-3	4-10	3 4-8	62,010,915
September.	8	88	15	59,425	11.22	6,100	32,150	38,250	17,529,375	24 3-8	58 1-2	4-10	3 3-8	62,199,649
October.	6	61	10	42,358	11.54	5,000	23,700	29,500	12,895,610	24 7-8	58 1-2	4-10	3	60,285,137
November.	8	80	20	53,932	11.19	5,500	31,700	38,600	15,909,940	24 1-4	58 1-2	4-10	2 4-8	57,319,194
December.	4	39	30	27,405	11.56	3,300	15,700	19,000	8,084,475	24 1-2	58 1-2	4-10	1 2-8	58,661,563
Totals and Averages.	55	564	15	386,180	11.465	46,325	222,375	269,900	120,222,100	24.19	58 1-4	4-10	20 3-8	58,429,365

The citizens of New Bedford are to be congratulated upon the possession, in connection with the Water Works, with one of the most effective Pumping Machines, both in design and execution, that there is in existence. It has no complicated attachments, and is not liable to have any of its parts get out of adjustment.

THE STREET MAINS.

The Street Mains were all laid under a contract with George H. Norman. In the cast-iron pipe, a number of leaks have occurred during the season,—a few caused by the blowing out of plugs, and some by the absence of lead in the under side of the joint.

The wrought-iron cement lined Street Mains have given us no trouble during the past year, from any imperfection in construction. It was fortunate for the City and for the contractors, that the services of Mr. Johnson Davee were secured for laying the pipe, the permanence of which so greatly depends upon faithfulness in this part of the operation.

The only leaks which have occurred on this kind of pipe, were on the twelve-inch Main near the *Greystone* property on County, Robeson and Ashland Streets, all within a few hundred feet of each other.

The leaks were in a measure owing to the very bad state of the weather at the time the pipes were laid, and to the use of cement injured by age.

This kind of pipe has fully answered the expectations formed of it, and bids fair to be durable. It certainly is strong enough to stand the pressure of any ordinary concussion of water, which may be brought against it; and will not be likely to obstruct the flow of water by corrosion.

The principal objection to their use, is their liability to injury when openings are made near them for sewerage or other purposes. A blow with a pick would be likely to open a hole in them, and an injury to the cement lining will bring the water into contact with the iron which will soon be destroyed by corrosion.

Great care should be taken in all operations in the streets, which expose the Mains to such injury; and it would be well to have such an understanding between those who have charge of the sewerage, and those who have the oversight of the Mains, as will secure them against this liability.

At the opening of the year, mainly owing to the fact that they could be obtained at a reduced price, the Board decided to make use of the cast-iron pipes. Twenty-eight thousand four hundred and eighty-nine feet have been laid the past year, on which no leak has occurred. The pipes are now in good order with the exception of a place on South Water Street near Howland, where a leak has for a short time existed which will have attention as soon as the state of the ground will permit.

STOP VALVES.

The Stop Valves used are from the workshop of the Boston Machine Company. One hundred and fourteen have been put into the Mains, and they are all in good order.

HYDRANTS.

The Hydrants in use are of the Flush pattern, and are placed under the sidewalks.

Of the whole number, ninety were made by the Stover Machine Company of New York. About thirty of those first sent gave us some trouble, the bolts breaking which work the valve rods, by reason of the imperfection of the metal.

The Hydrants had by us of the Boston Machine Company have been, like all the other work from that company, fully up to the guaranty. There are now set in the streets one hundred and twenty-seven Fire-Hydrants, and six on private property, belonging to the parties upon whose premises they are placed.

SERVICE PIPES.

Five hundred and fifty-three Services have been attached to the Mains. Of this number *four hundred and thirteen* are lead pipe, and *one hundred and forty* of wrought-iron gas-pipe lined and covered with cement mortar. Two leaks only have occured from imperfect work in putting on the taps and fitting the bands around the pipes.

The severe cold weather has frozen up some of the Service Pipes; generally, however, by reason of carelessness on the part of the occupants of the premises.

As far as my knowledge has extended, the comparison in this respect of the two kinds of pipe, shows a decided advantage in favor of the lead. The proportion is *two* per cent. of the one and *nine* per cent. of the other.

The question as to what kind of pipe is most suitable for this purpose has been here, as elsewhere, very earnestly discussed.

As you will, in your Report, give the subject a careful examination, my remarks upon it will be very brief.

Should we confine ourselves, in the investigation, to our own experience, it would be, as I conceive, decidedly in favor of lead pipe. But our experience has been limited and may therefore be put one side.

But we shall find this opinion confirmed in whatever direction we prosecute our enquiries. All the large cities of our own country, after an experience extending nearly to half a century, have settled the question in favor of lead.

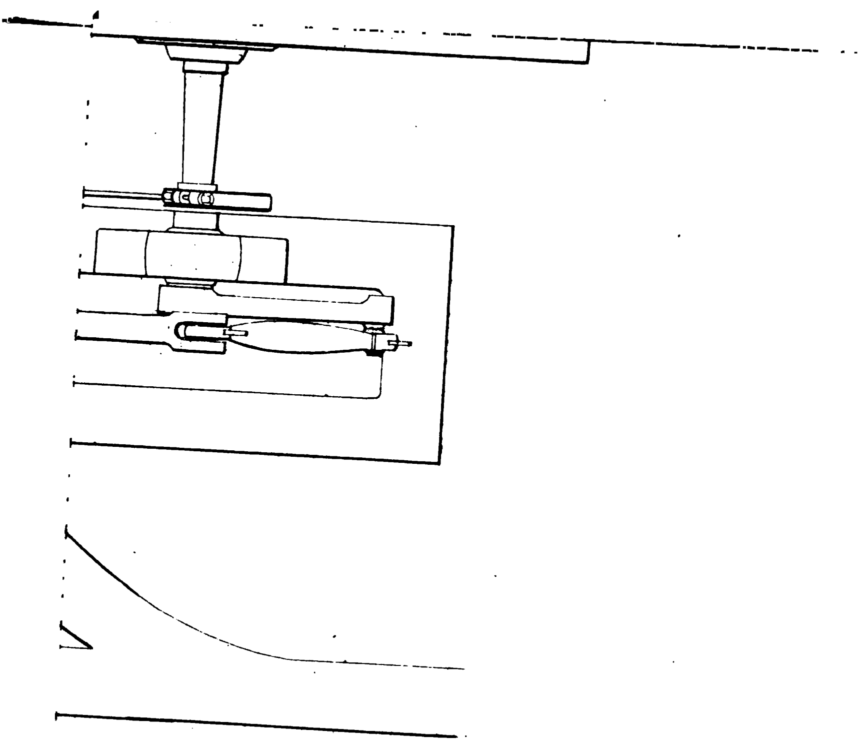
Abroad the result has been the same. In London and in other cities of Great Britian, no other metal is used, and at Paris and Rome and other continental cities, lead is the only metal in common use. Here we have the experience of centuries, and of the most important cities of our own and other countries tending to the same result. The objections to the use of lead for this purpose, are not founded upon any fact in any way applicable to the Acushnet water.

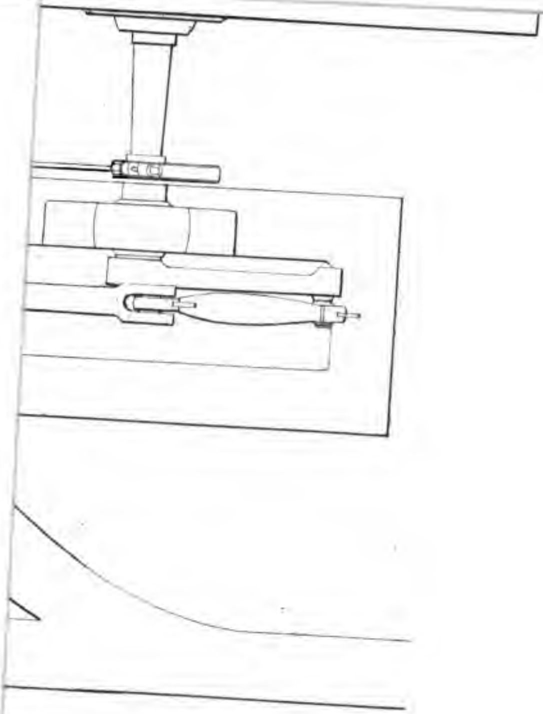
To preserve the purity of the water in our Reservoir, care must be taken to guard against all trespassers, and against any use of it inconsistent with this important point.

No vigilance must be spared that may be required to the full attainment of this end.

All of which is respectfully submitted.

GEORGE A. BRIGGS,
Engineer and Superintendent,
New Bedford Water Works.





REPORT ON THE PUMPING ENGINE.

INTRODUCTION.

1. On the 7th day of December, 1869, several gentlemen having come together in the City of New Bedford at the invitation of William J. McAlpine, Esq., for the purpose of conducting some experiments with the Pumping Engine of the City Water Works, then nearly completed, the following letter was presented to them as their credentials and instructions:

2. NEW BEDFORD, Dec. 7, 1869.

To the Board of Examiners:

GENTLEMEN, —By permission and direction of the Water Commissioners of New Bedford, I have to invite you to examine the new Pumping Engine for their Works, and to make such trials as you deem proper.

The Engine will be placed in your charge. Mr. Wilson on behalf of the Contractor, and myself in behalf of the Commissioners, will attend, to furnish any information or assistance that you may require.

On behalf of the Contractor it is suggested that his contract requires two conditions:

1st, that of capacity; 2d, that of economy.

In the first it is required that two millions of gallons of water shall be lifted into the Reservoir in ten hours with steam at an initial pressure of twenty pounds, following for one-third of the stroke, against a constructive head of 155 feet; and second, that the Engine shall perform sixty millions duty with one hundred pounds of good anthracite coal; such duty to be determined by the delivery of the water in the Reservoir, with an allowance of five *per cent.;* the load on the Pumps to be calculated by the pressure due to the lift of the water, including an equivalent head to represent its friction.

A copy of the contract is herewith submitted.

It is suggested that your examinations shall be made so as to determine the extreme capacity, and also the economy of the Engine, Pumps, and Boilers, independent of the terms of the contract.

It is also suggested that your experiments should be made with the Engine running at different rates of speed at which it can be judiciously run.

In designing this machine I have been governed by three leading principles. 1st, to make the water piston move at considerably less velocity than the steam piston. 2d, to convey the water to, through and from the Pumps with no changes of direction or form of volume that can be avoided. 3d, to expend as nearly as possible the whole power of the steam during each stroke, and produce in the water-pump piston a slow commencement, increasing speed to the middle of the stroke, and a gradual reduction, so as to have the Engine pass its centres with the least velocity.

The machine as built is believed to be strong and well proportioned, simple in construction, not liable to derangement, and requiring only ordinary skill in operating.

In your examination I respectfully request the consideration of how far these principles should be carried, so as to obtain the most economical results, with reference to the interest on the first cost, the expense of operating, and the liability of derangement.

The above suggestions are not intended to confine your consideration of the subject, but you are at liberty and you are requested to carry them as far as you deem advisable.

Respectfully yours,

WM. J. McALPINE, Consulting Engineer.

3. The Committee consisted of the following gentlemen, Mr. Charles Hermany, who came to witness the trial, kindly consenting upon urgent invitation to take part in it, and rendering most valuable assistance:

James B. Francis, Lowell, Mass.
D. M. Greene, Troy, N. Y.
Chas. H. Haswell, New York.
Charles Hermany, Louisville, Ky.
J. C. Hoadley, Lawrence, Mass.
Joseph Belknap, New York.
George H. Norman, Newport, R. I.

Mr. J. C. Hoadley was chosen Chairman; and Mr. William Rotch, who kindly consented to serve in that capacity, was appointed Clerk, and rendered very laborious and valuable assistance.

DESCRIPTION OF THE ENGINE.

4. This is a Beam Engine, having the beam centres supported by a stout hollow column of cast-iron, which serves as an air-chamber. The diameter of the steam cylinder is 38 inches, with a stroke of 8 feet. The valves for regulating the admission of steam to the cylinder, are adjustable, so that the cut-off may be set by hand with great delicacy at any desired point, and each end by itself, by which means the balance of the Engine may be nicely adjusted,—an essential feature, as will be seen. The balance-wheel is 16 feet diameter, and weighs 12 tons, and running at only about 13 revolutions per minute, its momentum is small, so small that the Engine passes its centres very slowly. It was found, by an ingenious method of observation, suggested and carried out by Mr. Wm. Rotch, that the speed of the crank-pin during the two quarter-revolutions at the upward and downward point of the crank, was about one-half that during the intermediate quarter-revolutions. Slow as was the motion in passing the centres, it was found that the Engine, when care-

fully balanced and left undisturbed, ran steadily and smoothly, always passing both centres with uniform reduction of speed, and allowing the pump-valves to close very easily and quietly.

5. This balance was very sensitive, and was occasionally disturbed during the experiments by the unequal admission of air to the two Pumps through the suction pipes. Upon the occurrence of any such disturbance, the Engine ran past the two centres with unequal speed, causing a violent closing of the pump-valves on the centre, when the speed was not sufficiently reduced, and danger of stopping, or actual stopping of the Engine on the other centre, when the speed was reduced too far. This disturbance would never arise in regular work, and is only mentioned to show the nicety of adjustment of which the Engine is susceptible.

6. The air-pump is 27 inches diameter and 34 inches stroke.

The water-pumps are 28 inches diameter and 4 feet 8 inches stroke, placed 15 feet 6 inches apart, 7 feet 9 inches each side of the beam centre.

The air-pump is placed between the water-pump and the central column on the end opposite the cylinder, its centre being 4 feet 9 inches from the beam centre.

The suction pipes are 24 inches diameter. The delivery pipes are 16 inches diameter.

7. There are no guides for the piston rods of the air-pump or water-pumps above the stuffing boxes. During the trial, the work being quite new and unworn, and the friction of the pistons probably excessive, there was some not very objectionable tremor about these rods at their downward motion; but after a few weeks' use this tremor became, it is said, noticeably less, and almost ceased to be observable.

8. The whole design is characterized by extreme simplicity, and the execution by good workmanship; and sound judgment is as clearly shown in what is omitted as in what

presents itself to the eye. The arrangement for adjusting the cut-off appears to be inconvenient, and would certainly be found so if frequent adjustment were required.

During the trials, this was the case, as it was desired to run with various velocities, and at different degrees of expansion. But in practical working, a convenient point of cut-off and a suitable speed having been determined, the engineer will probably find little trouble in the adjustment of the expansion gear.

DESCRIPTION OF THE BOILERS.

9. There are two boilers, each 6 feet diameter and 18 feet long, having 38 flues 5 inches internal diameter, arranged in squares, or in vertical and horizontal rows, placed 6¾ inches apart, centre to centre.

The grates are 5 feet wide and 5 feet 6 inches long. This area was found to be too great at the trial, and marked improvement resulted from a reduction first of 13 *per cent.*, and finally of 20 *per cent.*, which was effected by covering a part of the length of the grates at the back end for their whole width with a wall of fire-brick laid dry, but packed closely.

At the trial no dampers had been provided for regulating the supply of air below the grates. In consequence of this omission, and of the excessive area of grates, it was necessary on the first day of the trial to keep open the up-take door much of the time to prevent waste of steam at the safety-valve. This was of course attended with much loss of useful effect from the coal consumed. On the second day this defect was in great measure remedied by reducing the open area of grate in the manner above described, and by building a dry wall of brick in the mouth of the ash-pit; and fully remedied on the third and subsequent days of the trial; and the increased economy of fuel in the later trials was doubtless due in no small degree to that cause.

10. The water is conducted from the Storing Reservoir, a distance of 5⅝ miles, in a brick Conduit of oval section 4 feet high and 3 feet wide, having a uniform descent of 3 feet 3 inches, equal to 0.58 feet per mile. There is a waste-weir or overflow in the Conduit, about midway, so that the water, when none is admitted from the Storing Reservoir and none drawn from the Receiving Reservoir, finds its level in the Conduit with a depth of six inches at the upper end and three feet nine inches at the lower end.

When the Engine was started, the surface of the water in the Receiving Reservoir was gradually lowered until it attained a depression of one foot or a foot and a half, and until such a slope was established in the surface of the water in the Conduit as to restore the equilibrium between supply and demand.

From the Receiving Reservoir to the Pump-Well, the water is conducted in a stone culvert of ample section, a distance of 269 feet. No perceptible fall was produced in this culvert by the action of the Pumps.

11. The Pumps are single acting, having each three butterfly valves, namely, a foot-valve, a plunger-valve and a delivery-valve, with their seats inclined at an angle of 30 degrees with the horizontal, and rising 30 degrees when fully open. The cylindrical opening of the valves is 21 inches diameter with an obstruction across the centre of about 6 inches in width; as free a passage for water, perhaps, as any form of valve would give.

12. The change of direction from the vertical to the horizontal, and the reduction from the diameter of the Pump, 28 inches, to that of the Main, 16 inches, are made in a tapering quarter turn of 26 inches radius at its axis. This change of direction is 90 degrees, and the reduction of area 67 *per cent.* The only other essential change of direction, is a horizontal curve of 24 feet radius and a deflection of 45

degrees. From this point the Main preserves a uniform diameter of 16 inches, and rises with a slope very nearly uniform save a short distance at each end, where it is nearly or quite horizontal, 123 feet above the surface of the Receiving Reservoir when at rest, in a distance measured along the Main itself, of 1931½ feet.

The pipes from the two Pumps unite at a small angle, and in a manner to cause the least practicable obstruction to their combined flow. There is a throttle-valve in the Main above the junction of the two streams from the Pumps, to relieve the pump-valves of the hydraulic ram caused by the transition from a state of motion to a state of rest of the water in the Main on stopping the Engine. This throttle-valve causes a little, but only a little obstruction to the flow of the water.

13. The Pumps are required, by the contract, to lift two million gallons in ten hours, which necessitates a velocity of water in the 16 inch Main of 5.32 feet per second,

$$\frac{2000000 \times 231}{[\frac{\pi}{4}(16)^2 = 201.0624]\ 12 \times 10 \times 60 \times 60} = \frac{462000000}{86858956.8} = 5.319$$

and gives rise to a frictional resistance of about twenty feet. This at first sight appears excessive, and the introduction of a Main so small as sixteen inches, gave rise to some criticism and much discussion. It was at first thought by many members of the Committee that a larger Main would have been judicious.

14. But a careful consideration of all the circumstances leads to a different conclusion. Although sufficient power and capacity were provided to raise two million gallons in ten hours, it is not expected that more than one-half of this quantity will be actually required for many years. By running the Engine at a less velocity when less than the full capacity is required, the velocity of water in the Main may be reduced to one-half and the frictional head to one-fourth of the amount stated in Section 13.

15. Again: a considerable portion of the water required to pass through the Pumps for the supply of the City, will never have to pass through the sixteen-inch Main at all, but is led out of the Main just above the throttle-valve, near the Engine-House, by a ten-inch pipe, which passes down Purchase Street for the supply of the lower part of the City. Although under the full head due to the elevation of the Reservoir, and, while the Pumps are in action, to whatever frictional head there may be in addition, the water drawn through this ten-inch pipe relieves the sixteen-inch Main to a proportionate extent, and by lowering the velocity, reduces the frictional resistance.

16. The extent of this reduction of velocity in the sixteen-inch Main, which will result in practice from the diversion of water through the ten-inch pipe, will depend upon the quantity of water so diverted, and will vary with the varying requirements of the portion of the City supplied by the ten-inch pipe. Since this pipe supplies the densest and busiest part of the City, the draught upon it will be heaviest at just those hours when the Engine and Pumps will ordinarily be in action.

The areas of cross-section of the two Mains are as $(16)^2$ to $(10)^2 = 256$ to 100, nearly 13 to 5.

If, therefore, water be drawn through the ten-inch pipe, while the Pumps are in such action, as would produce a velocity in the 16 inch Main alone of 5.32 feet per second, so that the velocity is equal in the two Mains, that velocity will be reduced from 5.32 feet per second, to about

$$\frac{13}{13+5} \times 5.32 = 3.83 \text{ feet per second;}$$

and since the frictional resistance is directly as the square of the velocity, this resistance will be reduced as

$$(5.32)^2 : (3.83)^2; \text{ or as}$$
$$28.30 : 14.67; \text{ or about one half.}$$

In this view, the employment of a ten-inch lower Main in conjunction with a sixteen-inch rising Main, the latter acting as a standing column to maintain the pressure in the former, is substantially equivalent to the use of a rising Main of an area of cross-section equal to the combined areas of both Mains,

$$78.54+201.06=279.60, \text{ or}$$

nearly nineteen inches ($18\frac{7}{8}$ inches) diameter.

17. It was intended and desired so to conduct the experiments as to determine the relief of frictional resistance to be obtained by the use of this ten-inch Main; but owing to circumstances not fully explained, this could not be done, and the trials were all made with all the water passing into the Reservoir through the sixteen-inch Main. Although the frictional resistance, as measured by the difference between the static and dynamic head, (see Table VI, Data for Estimating Duty,) is thereby shown in the trials to be greater than it will be in the practical working of the Engine, perhaps in the proportion of two to one, and is so far unfavorable to the arrangement as a whole, and unless taken into consideration, unfair, it yet causes no injustice to the Engine either in point of capacity or duty, since both are calculated with reference to the dynamic head.

18. It will be obvious on reflection that both sources of relief from the excessive frictional resistance found in the trials, twenty feet,—that described in Section 14, namely, running the Engine at reduced speed, and that described in Sections 15, 16, namely, the diversion of water from the rising Main by the Purchase Street Main, may be brought into effect simultaneously. At such times, sufficient water being pumped to supply a current in the sixteen-inch Main alone of $\frac{5.32}{2} = 2.66$ feet per second; and part of the water diverted, reducing the velocity in both Mains to $\frac{13}{18} \times 2.66 =$

1.92 feet per second; the frictional head will be reduced from 20 feet in the proportion of

$$(5.32)^2 : (1.92)^2, \text{ or}$$
$$28.30 : 3.69,$$

or say to 2.60 feet.

These considerations lead the Committee to the opinion that the use of a sixteen-inch rising Main was, in the actual circumstances, judicious, and more than warranted by the large saving of annual interest upon the cost.

THE TRIAL.

19. First day, Wednesday, December 8, 1869. On this day the Board merely observed and noted the working of the machinery. The Engine and boilers were in all respects under the control and management of the contractor. Steam was carried at about 25 to 28 pounds* in the boilers, and the combustion was controlled and regulated by opening and closing the furnace and up-take doors. An assignment of duties to the several members of the Board, with arrangements for occasional relief, provided for continuous and regular observation of all required facts in Boiler-House and Engine-Room, and the assiduous attentions of the Water Commissioners, in supplying refreshments at the Engine-House, gave them an opportunity to continue their observations without interruption during the whole period of each trial. This first day's work was merely tentative, and no notes of it are here presented.

20. Second day, Thursday, December 9. This was a "duty" trial. As on the previous day, the entire machinery, including boilers, was left under the control of the contractor, as it was deemed unfair to him for the Board to dictate with regard to the management of either the Engine or boilers.

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* The steam pressures given are above atmospheric pressure.

21. Fires were started at about 7 o'clock in the morning. At 9 A. M., steam having been formed and the Engine being in operation, the condition of the fires was carefully noted by Messrs. Hermany, Greene, and Hoadley, and the trial was regarded as commenced. Coal was served out regularly at intervals of one hour, and divided equally between the two furnaces. The furnaces were fired alternately at intervals of about half an hour, so that an interval of an hour was allowed between the firings of each furnace. Steam was carried very uniformly at about 29 pounds in the boilers.

22. Very early in the day it became apparent that suitable means had not been provided for controlling the combustion. In order to maintain nearly uniform pressure of steam in the boilers, it was necessary to keep the up-take door almost constantly open. This, while checking the combustion at the same time permitted the abstraction and waste of a large amount of heat from the boilers, and rendered it obvious during the progress of the trial that the resulting "duty" would be much lower than that justly due to the Engine with economical combustion of coal.

23. At 4 P. M., the fires and water being in the same condition as at 9 A. M., the trial, after a duration of 7 hours, was considered closed. The fires were then drawn, and the ashes carefully separated from the clinkers and unconsumed coal. The latter were together assumed to be equivalent to an equal weight of coal two-thirds burned. The weight of the refuse, then, was equal to the weight of the ashes *plus* two-thirds of the weight of the clinkers and unconsumed coal. The notes of this trial, neatly tabulated by Mr. William Rotch, will be found in Table I and in Table V, and the subsequent trials in Tables II, III, IV, and V.

24. The trials being in all cases begun several hours after the fires were lighted, it was necessary to determine the ratio of incombustible material in the coal by weighing the coal put into the furnaces during the entire day, and the refuse

taken out during the day and at its close. This was done during the first three days of the trial, as follows, the scales used having been first tested for accuracy and sealed by the City Sealer of Weights and Measures, and all the weights being taken and recorded by Mr. Reuben Howland, sworn Weigher, and by at least one member of the Committee on duty in the Boiler-House.

Coal put into the furnaces during the day,			
Dec. 9,		5582 lbs.	
10,		3701 "	
11,		4380 "	13663 lbs.
Ashes taken during the day,			
Dec. 9,		627 lbs.	
10,		541 "	
11,		574 "	
		1742 lbs.	
Clinkers and partially consumed coal taken out during the day,			
Dec. 9,	410 lbs.		
10,	283 "		
11,	298 "		
	991 lbs.		
One-third estimated to be combustible,	330 "		
Two-thirds considered incombustible,		661 lbs.	2403 lbs.
Total combustible put into furnaces during three days,			11260 lbs.
Deduct combustible estimated to be left in clinker and ignited coal,			330 "
Total combustible consumed in three days,			10930 lbs.
" incombustible taken out in three days,			2403 "
Total coal consumed in three days,			13333 lbs.

Then, combustible $= \frac{10980}{13388} =$ 82 per cent.,
Imcombustible $= \frac{2408}{13388} =$ 18 " "

25. First trial, December 9, seven hours.

Coal weighed out during the trial,	4500 lbs.
" returned to coal house,	585 "
" consumed during the trial,	3915 lbs.

Combustible consumed during the trial,
82 *per cent.* of 3915 = 3210 lbs.
Incombustible contained in coal consumed during the trial,
18 *per cent.* of 3915 = 705 lbs.
Coal burned per hour, $\frac{3915}{7} =$ 559 "
Coal burned per minute, $\frac{559}{60} =$ 9.32 "
Combustible burned per hour, $\frac{3210}{7} =$ 459 "
Combustible burned per minute, $\frac{459}{60} =$ 7.64 "
Duty per 100 lbs. of coal consumed, 46319356 foot-pounds.
Duty per 100 lbs. of combustible, 56504764 " "
Cut-off at 0.33.

26. Second trial, December 10, six hours.

Coal weighed out during the trial,	3300 lbs.
" returned to coal house,	565 "
" consumed during the trial,	2735 lbs.

Combustible consumed during the trial,
82 *per cent.* of 2735 = 2243 lbs.
Incombustible contained in coal consumed during the trial,
18 *per cent.* of 2735 = 492 lbs.
Coal burned per hour, $\frac{2735}{6} =$ 456 "
Coal burned per minute, $\frac{456}{60} =$ 7.60 "
Combustible burned per hour, $\frac{2243}{6} =$ 374 "
Combustible burned per minute, $\frac{374}{60} =$ 6.23 "
Duty per 100 lbs. of coal consumed, 56294788 foot-pounds.
Duty per 100 lbs. of combustible, 68674220 " "
Cut-off, at about $\frac{1}{3}$ stroke.

27. Third trial, December 11, six hours.

Coal weighed out during the trial,	3100 lbs.
" returned to coal house,	210 "
" consumed during the trial,	2890 lbs.

Combustible consumed during the trial,
82 *per cent.* of 2890 = 2370 lbs.

Incombustible contained in coal consumed during the trial,
18 *per cent.* of 2890 = 520 lbs.

Coal burned per hour, $\frac{2890}{6} = 482$ "
Coal burned per minute, $\frac{482}{60} = 8.03$ "
Combustible burned per hour, $\frac{2370}{6} = 395$ "
Combustible burned per minute, $\frac{395}{60} = 6.58$ "
Duty per 100 lbs. of coal consumed, 59074333 foot-pounds.
Duty per 100 lbs. of combustible, 72092233 " "
Cut-off at 0.31.

28. Fourth trial, December 14, six hours.

Coal weighed out during the trial,	2400 lbs.
" returned to coal house,	200 "
" consumed during the trial,	2200 lbs.

Combustible consumed during the trial,
82 *per cent.* of 2200 = 1804 lbs.

Incombustible contained in coal consumed during the trial,
18 *per cent.* of 2200 = 396 lbs.

Coal burned per hour, $\frac{2200}{6} = 367$ "
Coal burned per minute, $\frac{367}{60} = 6.10$ "
Combustible burned per hour, $\frac{1804}{6} = 301$ "
Combustible burned per minute, $\frac{301}{60} = 5.00$ "
Duty per 100 lbs. of coal consumed, 59336497 foot-pounds.
Duty per 100 lbs. of combustible, 72372322 " "
Cut-off at 0.54.

29. Of the many diagrams taken with the indicator, both from the Engine and from the Pumps, during the trials, a

few are presented, selected as fairly representative of the whole.

Fig. I. Diagram taken from both ends of steam cylinder, December 9, (first day of trial,) at 9 h. 40 m. A. M., showing the reduction of pressure previous to cut-off, due to "wire-drawing" through the partially closed throttle. The scale introduced, 12 pounds to the inch, is that belonging to the indicator used. A slight correction was found to be necessary, after the close of the trial, as hereafter mentioned.

Fig. II. Similar to Fig. I, taken December 9, at 12 h. 24 m. P. M.

Fig. III. Similar to Fig. I and II, and taken the same day, December 9, at 12 h. 15 m. P. M. There is a little less "wire-drawing." This diagram is taken from the lower end of the cylinder only; but the companion diagram could not have varied essentially, as the Engine would not pass its centres unless the power developed in the cylinder was almost exactly equal at the two ends, and the diagram is a very clear, distinct, single line.

Fig. IV. Diagram taken from both ends of steam cylinder, December 14, at 10 h. 30 m. A. M. Cut-off at 0.52.

Fig. V. Diagram taken from west Pump, December 9, at 1 h. 55 m. P. M. This diagram was taken at the up-stroke of the pump-piston, from the delivery pipe above the delivery-valve, and shows the dynamic load on the pump-piston except the "suction," which is not here shown.

Fig. VI. Diagram taken December 9, at 1 h. 57 m. P. M., in the same position as Fig. V, but at the down-stroke.

Figs. VII, VIII. Similar to Figs. V and VI, respectively, taken December 9, at 1 h. 59 m. and 2 h. 0 m.

Fig. IX. This interesting diagram was taken from the east Pump, December 10, at 12 h. 25 m. P. M. The upper lines were taken from the pipe above delivery-valve; one at the up-stroke and the other at the down-stroke; the latter,

showing the load on the piston of the other Pump, except the suction. The oscillations at the commencement of each stroke, show the effect of the momentum of the reciprocating parts of the indicator, which is seen to have been in fine condition. The lower line, below the atmospheric line, shows the amount of vacuum, or "suction," caused by lifting the water below the Pump-piston from the well to fill the Pump. This line is double, formed by two strokes of the Pump, and their remarkable smoothness and uniformity show the admirable working of the indicator. This diagram was measured with extreme care, by the aid of a good pocket microscope, each line by itself, referred to the atmospheric line; and again over all, or "whole card," taking the mean of the two lines at each point of measurement. The mean pressure by one method was 59.70 lbs., by the other 59.72 lbs.

Fig. X. Diagram taken from west Pump, December 10, at 1 h. 5 m. P. M. The upper line, beginning with oscillations at the left hand, was taken from the pipe above the delivery-valve, and is similar to the corresponding line in Fig. IX. The lower line, below the atmospheric line, shows the suction. The other line at top, beginning at the right hand, was taken from the barrel of the Pump, at the down-stroke. These diagrams, selected from a great number, will give a just idea of all.

The Indicators used, and the steam guages, were carefully tested at the close of the trials, by the American Steam Gauge Company, Boston, through the courtesy of Mr. H. K. Moore, Superintendent.

30. The plan and profile of the Water Works, and the plans and sections of Engine and Pumps, are from drawings furnished by the Water Board of the City of New Bedford. All the important dimensions of Engine and Pumps were verified by actual measurement by the Committee.

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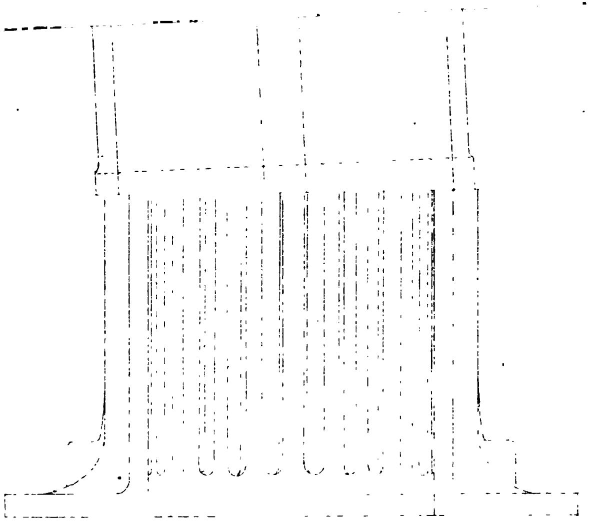
PLAN OF F

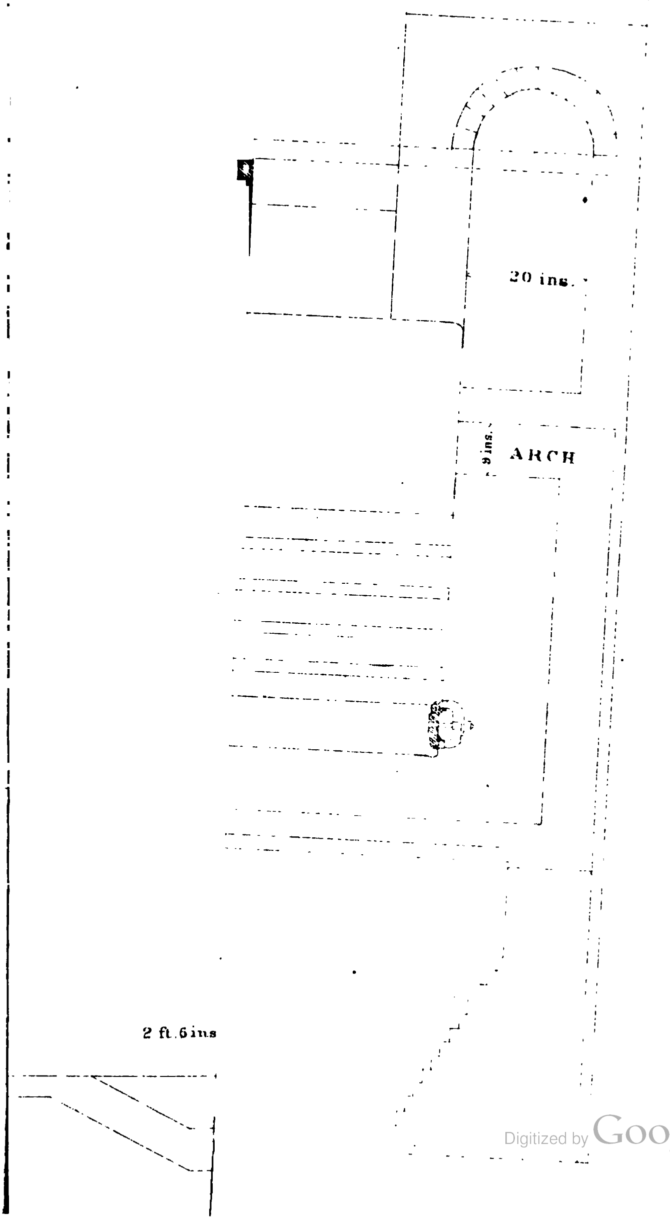


Scale, 1½ ins.=2 feet.

EDFORD WATE

PLAN OF BOILE

cale, 1½ in. = 1 fo



Observations were taken of the height of the water in the Receiving Reservoir at the beginning and end of the several trials; but the irregular form of this Reservoir, and the newness of its banks, presented difficulties in obtaining the quantities, and this method of estimating the quantity of water delivered was abandoned.

No facilities were provided for measuring the quantity of feed-water admitted to the boilers.

The brief duration of the trials, only six or seven hours each, led the Committee to use very great care to avoid, as far as possible, those errors of observation to which such experiments are liable.

The liberal and enlightened policy of the gentlemen composing the Water Board, in affording facilities for conducting these trials and in providing for their publication, merits the warm commendation of the engineering profession and of the public, since no question possesses a more universal interest than that of economical water supply.

J. C. Hoadley,
D. M. Greene,
Chas. H. Haswell,
Charles Hermany,
James B. Francis,
Joseph Belknap,
Geo. H. Norman.

APPENDIX.

APPENDIX.

The review, from which the following extracts have been taken, was prepared by Roswell E. Briggs, Civil Engineer, who was at one time connected with the New Bedford Water Works.

Mr. McAlpine thus speaks of it. "I have carefully examined this paper, and fully agree with the author in the statement of the principles which should govern in the construction of Pumping Engines, in the facts stated, and in the arguments advanced in favor of the principles enunciated. I take the liberty of recommending it to the perusal of those engaged in the planning and construction of works of a similar character."

The extracts are here published with the belief that they will aid in obtaining a correct knowledge of the Pumping Engine of the New Bedford Water Works.

EXTRACTS FROM A REVIEW OF THE McALPINE PUMPING MACHINE.

The duty to be performed by a Pumping Machine is peculiar, and differs materially from nearly all the other applications of steam power.

The resistance to be overcome is nearly constant, and the power, at all times, must be at least equal to this load.

At every change in the direction of the movement of the piston of a water pump (that is, at the end of each stroke), the momentum of the water in and near the pump which has been absorbed, is destroyed, and at the commencement of the succeeding stroke, the power is first exerted to develope the inertia of the water and again set the column in motion.

These changes take place in all reciprocating pumps, and a primary object in the arrangement of a Pumping Machine is to reduce the resistance from these changing motions to a minimum.

Steam working expansively, meets the requirements of a reciprocating pump exactly.

When first admitted into the cylinder, it has a pressure much greater than that due to the weight of the column of water against which it is to act. The inertia of the water is therefore rapidly overcome, and so long as this higher degree of pressure is continued, so long does the velocity of the water continue to increase, and thus absorbs the excess of the power in its own momentum. The supply of steam being shut off from the cylinder, that which it contains, continues to exert its pressure against the piston, but expanding as the steam space increases, its pressure is gradually diminished, until it falls below that due to the normal weight of the water load on the pump, at the beginning of the stroke.

The excess of power beyond the resistance of this normal weight, which has been developed at the beginning of the stroke and treasured up in the momentum of the water, fly-wheel, and moving parts of the machine, is yielded up during the remainder of the stroke, and aids the waning power of the steam to force up the column of water.

The speed of the piston is gradually diminished, and if the cut-off is properly adjusted, the whole power at the end of the stroke will be just sufficient to turn the centres and open the valves very slowly and with no excess of power.

The operation thus described, is the perfection of movement in a reciprocating Pumping Machine. The slowness of motion at each end of the stroke opens and closes the valves without noise, injury, and the least loss of water; the water in the pump-chamber has lost its motion, and the piston begins the return stroke through water almost at rest, and with the minimum degree of friction, while the moving parts of the machinery are gradually brought to a state of rest, without concussion or injury.

The resistances to be overcome by the power of a Pumping Engine are:

First. The inertia and the friction of the several parts of the machine.

Second. The elevation of the water.

Third. The inertia and the friction of the water through the pumps, valves, connecting pipes, and force main.

When steam is applied to this purpose, the increased power which may be derived from its expansion, should be availed of to the greatest practicable extent; but where reciprocating pumps are used the excess of power beyond the resistances, developed by the initial pressure of the steam, must be exhausted at the termination of each stroke to produce the best results.

The absorbents of this surplus power are;

First, and chiefly. The momentum of the ascending columns of water.

Second. The momentum of the moving parts of the machinery, except that of the fly-wheel.

Third. The momentum of the fly-wheel.

And lastly. The compression of the air in the air-vessel, and also the surplus power expanded in the extra elevation of the water in the standing column.

With reciprocating pumps it should be arranged, so that the surplus power of the steam engine thus absorbed, is again given out before the commencement of the next stroke, and all of it contained in the momenta, except a very small portion of that in the fly-wheel (by a proper adjustment,) may be applied to aid in overcoming the resistances of the ascending column of water.

The extent to which the expansion of the steam may be carried, will be determined by the amount of the absorption of the excess of the initial power in these different momenta and its release during each stroke.

It will probably be found that an expansion of three times in the steam cylinder, will produce the maximum degree of useful effect; but the most useful rate of expansion in any particular steam engine, can only be definitely determined by direct trial.

Direct-acting pumps are used to avoid the loss of power in the friction of the machinery necessary to convey it to them; but the practical difficulty of always maintaining the steam and water pistons in perfect alignment, probably causes as much loss of power as would be incurred in its transmission to an indirect-acting pump; and as it is impossible to move water at the same velocity as steam without a serious waste of power, direct-acting pumps are objectionable.

The ordinary beam engine affords the means of giving the proper velocity both to the steam and water pistons, with only two extra journals, both of which have a slow movement of less than five degrees, the friction of which is therefore inconsiderable.

The vertical beam engine has also two advantages over one working horizontally, viz., in avoiding the friction due to the weight of the pistons resting on the lower part of the cylinders, and in giving an opportunity to absorb more of the surplus initial power, in the momentum of the vertically moving parts of the machine.

It also allows the moving parts, on the opposite sides of the beam centre, to be accurately balanced. It permits of extreme simplicity in its construction, all the parts of which are nearly of the same form as those of the most numerous class of steam engines in use, and of giving convenient access to all of its parts, with none of them liable to undue wear or strain, and with the least loss of power by friction, and it permits, almost without extra cost of construction, a large increased velocity without danger, and also a very low velocity without much waste of power.

Reciprocating pumps of three classes are used, viz.: single, double-acting, and plunger. In the first the water is lifted by a valved piston; in the second by a solid piston, which alternately lifts and forces the water, and in the third by a solid plunger, which displaces the water in the pump-chamber, and forces it out through the upper valve.

All Hydraulicians agree that it requires an increased amount of power to force water through a pipe, whenever the area of its volume or its direction is changed, and that even a sudden enlargement causes an obstruction, in some cases as great as a contraction.

The importance of avoiding all abrupt changes of volume, or direction in water pipes, is fully recognized in the practice of all skilful engineers, in the arrangement of their main and distribution pipes. In the former, all changes of direction are made by curves of large radius; and in the latter, the entrances to the crossing pipes are always made with as large a radius as the case will admit.

On this subject, Daubicisson says: § 196, "Every moving body which, after following one direction, suddenly changes it, loses a part of its velocity." * * * * "If however, a fluid follows a curved line, this loss, although real, will usually be very small." * * * * * "Rennie's experiments show that a single abrupt right angle reduces the discharge more than fifteen semicircular curves of a radius six times the diameter of the pipe." * * * * "The effect of enlargements in a conduit pipe, are quite as prejudicial as that of contractions taken above a certain limit."

Other writers assert that the obstruction caused by an abrupt bend, is six times as great as when made by a gentle curve, giving the same amount of deflection.

The civil engineer rarely determines more than the general style of the pumps, and usually leaves to the practical mechanic the arrangement of the direction and form of the water passages. As these are analogous to his steam passages, he is naturally led to arrange them alike, forgetting that in one case he is dealing with an *elastic vapor*, which loses but a small portion of its force in these diversions, while in the latter he is dealing with an *incompressible fluid*, where the loss is comparatively very much greater. Hence we find him forcing water through his pumps with a dozen changes of volume and direction, which the engineer would consider totally inadmissible after the water leaves the delivery pipes of the pumps.

In a single-acting pump the direction of the water is not changed, and in a plunger pump there is but one change of direction. In a double-acting pump there must necessarily be changes of direction, equal to five right angles, which at every revolution, twice destroys all the acquired momentum of the water.

The single-acting pump has one more valve passage than the others, and with butterfly-valves its volume is divided into two semi-cylindrical columns at each; and has two extra slightly abrupt changes in the volume of the water in passing through the bucket-valve in the piston, to offset against the five right angles of the double-acting pump, or the one right angle in the plunger pump. The single-acting pump will therefore deliver the same quantity of water, with expenditure of less power, than the plunger pump, and very much less than with the double-acting pump.

It has been stated that the single-acting pump delivers the water with no change of direction. In practice, however, it is necessary to extend the vertical delivery pipe to a horizontal direction, which gives the same number of changes of direction as in the plunger pump; but this change is made in the former on a gentle curve, and in the latter by an abrupt angle.

The English mechanicians almost universally use what are termed balanced double-beat valves. These valves divide the ascending column of water into two parts, one cylindrical and the other annular, and both of them are forced through three abrupt right angles before they are again united in the solid column above the valve.

The American mechanicians have, to a considerable extent, followed the English practice, and extended it by making three beat, and in one case four beat-valves for pumps, and thus still further dividing the column of water.

Both mechanicians, however, use butterfly-valves in their air-pumps. This form of valve divides the column of water into two semi-cylinders, and places an obstruction in the middle of the pipe, which with a small but abrupt turn at the seating, causes some loss of power; about one-third of the weight of the valve has to be raised at each stroke; but the whole loss of power in these valves is very much less than in those of the double-beat form.

It is evident that an elastic, almost imponderous vapor like steam, can be moved with a greater velocity than an incompressible, ponderous fluid like water, and therefore in all direct-acting pumps the movement of the steam piston will be too slow, or that of the water piston too fast, to produce the most useful effect in the combined machine.

An approximation to the proper velocity to be given to the water piston, can be arrived at by an examination of the movement of the plunger of a Cornish pump. That kind of pumping machine consists essentially of two separate engines, each of which perform their functions almost independently of each other. The power of the steam is first applied to elevate a heavy weight, which is carefully graduated, so as to be slightly in excess of the resistances which are to be overcome in the elevation of the water. The movement of the first part of the descent of the plunger of the water-pump is the most easy, natural, and appropriate motion to overcome these resistances that can be devised. At the termination of each stroke (both of the pump and steam pistons,) there is a sensible pause, which allows the valves to quietly close. The plunger begins its descent with a scarcely perceptible motion, until it has developed the inertia of the water, and then gradually increasing the velocity of its descent as the resistances diminish and its own momentum increases, until it has obtained a regimen of velocity, which can be exactly regulated by the weights placed on the plunger.

The last portion of the stroke would be performed with too great a velocity if it was not checked by cushioning in the top of the steam cylinder. The average velocity of the plunger of Cornish pumps when properly loaded, is about one hundred and twenty-five feet per minute. This is also about the velocity of other well-arranged pumps of this size, both in this country and in Europe.

The natural movement above described is almost exactly imitated by the action of the steam in the New Bedford Machine, but the movement during the last part of its stroke is more perfect.

The standing column and air-vessel each perform the same function. The former permits the impulse of the steam at the beginning of the stroke to elevate a very short column of water to the extra height, due to the increased velocity of the pistons at this part of the stroke, instead of acting directly upon the longer column of the pump main. In the former case the inertia to be developed is only six tons, and in the latter it is nearly one hundred.

The compression of the air in the air-vessel accomplishes the same result.

It has sometimes been erroneously supposed that the excess of power thus communicated to these two adjuncts again usefully acts upon the ascending column of water in the pump main. It does act against the water in the main by this increased head in the standing column and by the increased pressure in the air-vessel, but each of these forces also react directly back upon the pumps with the same pressure, and they therefore exactly neutralize each other and produce no useful effect.

We will now proceed to the consideration of the McAlpine Pumping Machine, designed for the New Bedford Water Works.

This Machine has been arranged in accordance with the principles which have been enunciated in the preceding part of this paper.

It consists of a vertical, beam, condensing, expansive steam engine, and two vertical, single-acting pumps, one of which is placed on each side of the beam centre.

Its general dimensions are as follows: Steam cylinder thirty-eight inches diameter and eight feet length of stroke; working beam twenty-seven feet long and of seven tons weight; fly-wheel sixteen feet diameter and twelve tons weight; two single-acting pumps, each twenty-eight inches diameter and four feet eight inches stroke; air-pump twenty-seven inches diameter and thirty-four inches stroke; two cylindrical tubular boilers six feet diameter and eighteen feet in length.

The working beam centre is supported on a column of cast-iron, four feet in diameter and twenty-two feet high, bracketed and bolted to a cast-iron foundation plate thirty-six feet long and five feet wide, and to the bed-plate, eighteen feet long and five feet wide, and all resting on and bolted to massive walls of granite. This column forms both the condenser and air-vessel.

The pump centres are placed on the beam, at such distances as will give a velocity to the water piston of 116⅔ feet per minute, or rather fifty-eight and one-third per cent. of the velocity of the steam piston.

The practical mechanics have determined that the most judicious velocity of a steam piston for a steam engine of this size, is about two hundred feet per minute, and it has already been stated that the maximum rate of expansion should not exceed three times.

This pumping machine has been arranged to elevate two millions of gallons of water in ten hours, into the reservoir one hundred and thirty feet above the pump-well, through a pipe of sixteen inches diameter and twenty-two hundred feet long, the friction of which will increase the constructive head to about one hundred and forty-five feet.

For the first five years the demand for water will be but one-half of the above quantity, and at some future time it is believed that this demand will be quadrupled.

The steam engine has been arranged with special reference to these conditions, so as to consume the fuel to the best advantage under each of these conditions. Accordingly, the steam is intended to be used at a temperature which will give a pressure, at its entrance into the steam cylinder, of twenty pounds per square inch.

It will be observed by the plans of this pumping machine, that the water has but two changes of direction in passing from the pump-well through the suction pipe, valves, chamber, and delivery pipe, to the pump main. The first of these changes of direction is where the water leaves the vertical line of the pumps, and takes the horizontal line of the delivery pipe, and this is made by a curve of twenty-six inches radius, and ninety degrees of deflection. The second change is where the delivery-pipe is curved horizontally into the pump main, which is so placed as to accommodate a second engine which may hereafter be required. This curve made on twenty-four feet radius, is extended until it gives forty-five degrees of deflection.

It will also be observed that the cylindrical form of the water is not changed: It is however, split in two equal parts in passing through each of the three valves. Below each of them it is contracted by a gradual curved taper, and above the upper valve also by a gradual taper into the delivery pipe. An unavoidable sudden but small enlargement takes place when the volume of water passes the valve seat. When opened, the valves offer an obstruction in the centre of the column, which is more serious than all of the other obstructions put together, yet the whole arrangement of the valves offer much less obstruction than in any other reciprocating pump.

The Cornish pumps give at least five right angular turns to the water, and as many more in the valves, all of which are abrupt, with little or no curve. They also give four changes in the form of the volume of the water in passing through the pipes and pumps.

The Brooklyn pumps, and the new ones at Cincinnati and Chicago, and the Worthington pumps, have as many right angular turns and changes of the form of the volume as the Cornish pumps.

In the computation of the strength of the different parts of the machine, we find the moduli varying from eight to forty. This shows that none of the parts are overstrained, and that the load might be considerably increased without danger.

We also find the capacity of the pumps ample, as they allow 11 3-10 per cent. for leakage. This amount would not be reached unless the valves were very much worn. The best moving pumps and valves lose about four per cent. when in their order, and increase up to ten per cent. as they become worn.

The velocity of the steam piston is two hundred feet per minute; this corresponds very nearly with that determined by practical mechanics for engines of this size.

The velocity of the pump piston is 116⅔ feet per minute, or fifty-eight and one-third per cent. of the velocity of the steam piston. This corresponds nearly with that of the best arranged pumping machines in this country and in Europe.

The steam is intended to be used at a temperature which will give a pressure at its entrance into the steam cylinder of twenty pounds per square inch; and after adding the value of the expansion and of the vacuum, and deducting the friction of the machinery, it will give an average constant available power at the water piston, of twenty-five thousand pounds, or five million feet pounds per minute.

The average constant load of the water on the pumps, including that from the extra pressure produced by its friction at the velocity stated, is forty-one thousand five hundred pounds, or four millions eight hundred thousand feet pounds per minute.

The leverage of the beam gives an advantage to the steam pressure in the proportion of eight feet to four feet eight inches.

At the commencement of each stroke, there is resting upon the water piston the pressure due to the weight of a column of water of twenty-eight inches diameter and one hundred and thirty feet vertical height, which is equal to thirty-four thousand seven hundred and seventy-five pounds; and when this water has attained its average velocity of one hundred and twenty feet per minute, its pressure will be equal to forty-one thousand four hundred and sixty-two pounds.

The initial power of the steam on its piston, including its beam leverage, after deducting the other resistances, exerts a pressure of fifty-two thousand three hundred and sixty-two pounds against the column of water in the force main. This pressure continues for one-third the length of the stroke, and its surplus power beyond the resistance of the water is absorbed in giving momentum to the column of water (which weighs one hundred tons,) and to the beam, rods, and pistons, weighing together about ten tons, and to the fly-wheel weighing twelve tons, with a leverage of two to one, and the compression of the air.

In the second part of the movement, extending to a little beyond the centre of the stroke, the pressure begins with the same force as in the first part of the stroke, and ends with a pressure exactly equal to the resistance of the water.

On the last part of the movement (being nearly one-half the stroke,) the pressure begins at just equal to the resistance, and terminates with the end of the full stroke at a pressure about two-thirds of the resistance of the weight of the water.

The surplus of power developed during the first half of the stroke (except a small portion of that absorbed by the fly-wheel, and that which is absorbed by the compression of the air,) is exerted against the moving column of water in the pump main, and enables the waning power of the expanding steam on the last half of the stroke, to complete the stroke, and leaves a surplus in the fly-wheel of a little over one per cent. to turn the centres.

These pressures and resistances are approximately correct, but are only stated in this place in a general way, to describe particularly the absorption of the surplus power and its release.

The cut-off gear is adjustable, and will in practice be set so as to produce the effect desired, viz., to allow the piston to slow down at the end of the stroke, with only surplus power enough to turn the centre.

In summing up the principles upon which this Pumping Machine is constructed, we may say:

First. That it gives the most appropriate velocity to both the steam and water pistons.

Second. That it avoids all unnecessary changes in the volume and direction of the water.

Third. That it applies the expansion of steam to its most useful extent, and so as to produce the most natural movement of the water during the different parts of each stroke, and restores almost the whole of the momenta acquired in the first half, during the completion of the last half of the stroke.

Fourth. That it is a well-balanced machine, of extreme simplicity and accessibility to all its parts.

Fifth. That it is massive and strong, with none of its parts liable to undue wear or strains, and consequently of great cheapness in construction and maintenance.

Such a machine ought to show a duty at least equal, and probably superior to that of any other pumping machine in this country, and will doubtless compare favorably with the best ones of Europe.

The most recently built pumping machines in the United States are of the Cornish type, or those with direct double-acting pumps.

Those in England are generally either Cornish engines or vertical beam engines, with two cylinders and a single pump arranged with a plunger, and also with a valved piston. The Cornish machines have long maintained their character for giving a high duty. They are more expensive in construction and more difficult in management than any other.

The plunger and piston pump also conforms nearly to the governing principles which have been stated.

The Brooklyn pumping engine has a double-acting steam cylinder and two peculiar double-lift, single-acting pumps, and loaded pump rods like those used in the Cornish engines.

The Cincinnati machine is sixty feet high, with the water-pump, air-pump, and steam piston rods in one continuous vertical line. The pump is double-acting, and the machine is amenable to all the objections which have been before stated against direct and double-acting pumps, and also to the difficulty of maintaining its three pistons and four stuffing boxes in line.

The Chicago machine is composed of two distinct pumping engines, coupled at right angles with two direct double-acting pumps. To it also apply all of the objections stated to other direct-acting pumps; and also the further objection produced by the coupling of the two engines at right angles, which carries each of the pump pistons over its centre at the same velocity that it has in the other parts of the stroke, and forces the piston at the commencement of the return stroke with its maximum velocity against the water, which is flowing also with its maximum velocity in the pump chamber.

The Worthington double-pumping machine has all the objections which have been made to the Chicago machine, as well as those arising from the connection of three cylinders in one direct line, and the friction and wear of each of the three pistons arising from their horizontal position.

From the preceding discussion of the subject, it will be seen that the pumping machine which has been herein reviewed is more free from the objections which are above stated to the several types of modern engines, and conforms more strictly to the principles which have been enunciated, than any of the machines except the Cornish, to which in these respects it is fully equal, and to which it is superior in economy of construction and the safety and cost of maintenance.

LOCATION OF HYDRANTS.

Allen Street, S. E. corner of Bonney.
Ashland Street, W. side head of Linden.
Bedford Street, S. W. corner of Fifth.
Bedford Street, S. E. corner of County.
Bedford Street, S. E. corner of Orchard.
Bonney Street, N. W. corner of Grinnell.
Bush Street, S. W. corner of First.
Cannon Street, No. 15½ S. side.
Cedar Street, N. W. corner of Elm. Double.
Cedar Street, S. W. corner of Kempton.
Cottage Street, N. W. corner of Hawthorne.
Cottage Street, S. W. corner of Arnold.
Cottage Street, S. W. corner of Union.
County Street, N. W. corner of Locust.
County Street, N. W. corner of Parker.
County Street, S. W. corner of Smith.
County Street, S. W. corner of Maxfield.
County Street, S. W. corner of North.
County Street, S. W. corner of Middle. Double.
County Street, S. W. corner ot Morgan.
County Street, N. W. corner of Union.
County Street, W. side head of School.
County Street, N. W. corner of Bush.
County Street, S. W. corner of Hawthorne.
County Street, N. W. corner of Allen.
County Street, S. W. corner of Grinnell. Double.
County Street, W. side head of South.
Court Street, S. W. corner of Orchard.
Court Street, S. side head of Cedar.
Court Street, S. side head of Emerson.
Court Street, S. side front of Tannery.
Cypress Street, N. W. corner of Hillman.
Elm Street, S. side opposite Forbes' carriage factory.
Elm Street, S. W. corner of Pleasant.
Foster Street, S. W. corner of Maxfield.
Foster Street, N. W. corner of Charles.
Fourth Street, W. side opposite W. H. Sherman's stable.
Fourth Street, No. 73, W. side front of J. H. Dennison's.
Front Street, corner of Lane head of Merrill's Wharf.
Front Street, N. W. corner of Shepherd's Lane.
Front Street, S. W. corner of Centre.
Front Street, S. W. corner of Elm.

Grove Street, S. W. corner of Anthony.
Hazard Street, S. side opposite entrance to Hazard's Court.
Hazard Street, S. W. corner of Pleasant.
High Street, No. 34, S. side nearly front of George B. Richmond's.
Hillman Street, S. E. corner of Hill.
Kempton Street, S. side front of Pleasant.
Kempton Street, S. side head of Hill.
Kempton Street, S. W. corner of Summer.
Kempton Street, S. side head of Cypress. Double.
Maple Place, W. side front of John Hopkins'.
Maxfield Street, S. E. corner of Chestnut.
Middle Street, 218½ S. side.
Middle Street, S. E. corner of Second.
Middle Street, S. E. corner of Sixth. Double.
Mt. Pleasant Street, S. E. corner of Distributing Reservoir.
Mt. Pleasant Street, W. side front of Joseph Clark's.
Mt. Pleasant Street, N. W. corner of Durfee.
North Street, S. W. corner of Foster.
Orchard Street, W. side head of Bush.
Prospect Street, N. W. corner of Grinnell.
Prospect Street, W. side front of Mt. Washington Glass Works.
Purchase Street, near Pumping Engine-House.
Purchase Street, E. side foot of Clark.
Purchase Street, W. side head of Logan.
Purchase Street, N. W. corner of Austin.
Purchase Street, N. W. corner of Merrimac. Double.
Purchase Street, N. W. corner of Pope.
Purchase Street, S. W. corner of Pearl. Double.
Purchase Street, S. W. corner of Campbell.
Purchase Street, 209, W. side front of Capt. Kelley's. Double.
Purchase Street, S. W. corner of Hillman. Double.
Purchase Street, S. W. corner of Mill.
Purchase Street, N. W. corner of Middle.
Purchase Street, W. side front of Engine-House. Double.
Purchase Street, N. W. corner of Union.
Ray Street, N. W. corner of Maxfield.
Ray Street, W. side front of Gosnold Mills Office.
Ray Street, N. W. corner of Willis.
Ray Street, S. E. corner of Pope.
Ray Street, W. side near N. B. & T. R. R. Blacksmith shop.
Ray Street, W. side near N. end of Wamsutta Mill No. 4. Double.
Robeson Street, S. W. corner of County.
Russell Street, No. 52, S. side front of Charles Leach's.

S. Second Street, No. 10, W. side front of G. W. Furber's.
Second Street, N. W. corner of Coffin.
Sixth Street, S. W. corner of William.
Sixth Street, S. W. corner of School.
Sixth Street, N. W. corner of Bush.
Sixth Street, S. W. corner of Russell.
South Street, S. W. corner of Third.
South Street, S. W. corner ot Second.
Spring Street, S. W. corner of Seventh.
State Street, N. W. corner of Sycamore.
Sycamore Street, S. W. corner of Thomas.
Sycamore Street, S. W. corner of Summer.
Third Street, N. W. corner of School.
Third Street, N. W. corner of Bush.
Third Street, N. W. corner of Russell.
Third Street, N. W. corner of Bedford.
Thomas Street, N. W. corner of Hillman.
Union Street, S. W. corner of Water. Double.
Union Street, S. E. corner of Second.
Union Street, S. W. corner of Third. Double.
Union Street, S. W. corner of Sixth. Double.
Walnut Street, S. W. corner of Second.
Walnut Street, S. E. corner of Fourth. Double.
Walnut Street, S. W. corner of Seventh.
Walden Street, S. W. corner of Maxfield.
Water Street, S. W. corner of Hillman.
Water Street, W. side front of Hayes' stave mill.
Water Street, N. W. corner of Middle. Double.
Water Street, W. side front of S. P. Burt's Office.
Water Street, N. W. corner ot School.
Water Street, N. W. corner of Walnut.
Water Street, N. W. corner of Coffin.
Water Street, W. side head of Leonard. Double.
Water Street, N. W. corner of Howland.
Water Street, N. W. corner of Grinnell.
Water Street, N. W. corner of South.
Wamsutta Street, S. side opp. entrance to Wamsutta Mills Office. Double.
Washington Street, S. E. corner of Crapo.
William Street, S. W. corner of Eighth.
William Street, 26½ S. side front of Richard & Johnson's Eating Saloon.
William Street, S. W. corner of Bethel.
Willis Street, S. W. corner of State.

LOCATION OF STOP-GATES.

STREET.	16 in.	12 in.	10 in.	8 in.	6 in.	4 in.
Allen, W. side County,					1	
Bedford, E. & W. side County,					1	1
Bush, W. side County,					1	
Bush, W. side Water,						1
Cannon, W. side Water,						1
Campbell, W. side Purchase,						1
Cedar, N. side Court,					1	
Charles, W. side Purchase,						1
Commercial, E. side Front,						1
County, N. side Robeson,					1	
County, S. side Merrimac,		1				
County, S. side Hillman,			1			
County, S. side Union,				1		
County, S. side Bedford,				1		
Court, W. side County,				1		
Court, W. side Emerson,						1
Cottage, S. side Court,						1
Cottage, S. side Clinton,						1
Cypress, S. side Hillman,						1
Elm, E. side County,						1
Elm, E. & W. side Purchase,						2
Eighth, S. side Union,						1
Emerson, at Rope Walk,					1	
Foster, S. side Hillman,						1
Fourth, S. side Union,				1		
Fourth, S. side Walnut,				1		
Front, S. side Union,					1	
Front, at Steamboat Wharf,						1
Grinnell, E. side Water,						1
Hall's Court, S. side William,						1
Hawthorn, W. side County,						1
Hazard, W. side Purchase,						1
Hazard, E. side County,						1
High, E. side Purchase,						1
Hillman, E. side County,				1		
Hillman, W. side Purchase,				1		
House of Correction, S. side Court, 1 3 in.						
Kempton, E. side Cedar,					1	
Kempton, E. & W. side County,					1	1
Kempton, W. side Purchase,						1
Maxfield, W. side County,				1		
Maxfield, E. & W. side Purchase,						2
Morgan, W. side County,						1
Middle, E. side Cedar,						1
Middle, E. side County,					1	
Middle, E. & W. side Purchase.					2	
Middle, E. side Water,					1	

LOCATION OF STOP-GATES.

STREET.	16 in.	12 in.	10 in.	8 in.	6 in.	4 in.
Mt. Pleasant, S. side Peckham,		2				
North, E. side County,						1
North, W. side Purchase,						1
Pearl, E. side Purchase,						1
Pleasant, S. side Hillman,						1
Purchase, S. side Merrimac,			1			
Purchase, S. side Hillman,			1			
Pump Main, at Engine House,			1			
Pump Well, at Engine House,	2					
Ray, N. & S. side Wamsutta,				1	1	
Ray, at Wamsutta Mills,				1	3	
Ray, S. side Campbell,					1	
Ray, at Gosnold Mills,						1
Russell, W. side Fourth,						1
Second, N. & S. side Union,						2
Second, S. side Walnut,						1
Sixth, S. side Middle,						1
Sixth, S. side Union,						1
Sixth, S. side Walnut,						1
Sycamore, E. side County,						1
South, E. side County,					1	
Third, S. side Union,						1
Third, S. side Walnut,						1
Union, W. side Cottage,						1
Union, E. & W. side County,				1		1
Union, W. side Fourth,				1		
Union, E. side Purchase,				1		
Washington, W. side County,						1
Walnut, E. side County,					1	
Walnut, W. side Fourth,					1	
Walnut, E. & W. side Water,					2	
Wamsutta, E. & W. side Ray,				2		
Wamsutta, at Wamsutta Mills,					3	
William, E. side County,						1
William, E. & W. side Purchase,						2
William, W. side Water,						1
Willis, E. side County,					1	
Willis, E. side Purchase,					1	
Water, S. side Middle,					1	
Water, S. & N. side Union,					2	
Water, S. side Walnut,					1	
Water, S. side Griffin,					1	
Waste, County, N. side Smith,						1
Waste, Hillman & Water,						1
Waste, Court, Tripp's Brook,						1
Waste, Water, between Howland & Grinnell,						1
Distributing Reservoir, Gate House.	1			1		
	3	3	4	16	33	54

STATEMENT OF THE KIND AND SIZE OF THE DISTRIBUTING MAINS, AND OF THE NUMBER OF FEET OF EACH LAID IN EACH STREET.

Location of lines of Pipe.	Cast Iron Pipe.						Cement Lined Pipe.				
	16 in. Feet.	12 in. Feet.	10 in. Feet.	8 in. Feet.	6 in. Feet.	4 in. Feet.	12 in. Feet.	10 in. Feet.	8 in. Feet.	6 in. Feet.	4 in. Feet.
Allen Street, Bonney to County.										579	
Ashland Street, Durfee to Robeson.							1,180				
Anthony Street, Grove to Bedford.											405½
Bedford Street, Anthony to County.											889½
Bedford Street, County to Third.										1,148	
Bonney Street, Washington to Allen.											834½
Bush Street, County to Orchard.										524½	
Bush Street, Fourth to Water.						860					
Cannon Street, South Water to Second.						890					
Campbell Street, Purchase to State.						600					
Cedar Street, Court to Kempton.					1,050						
Charles Street, Purchase to Foster.						455					
Chestnut Street, Sycamore to Hillman.						590					
Commercial Street, Front east.						165					
County Street, Hazard to Robeson.					240						
County Street, Robeson to Hillman.							2,808				
County Street, Hillman to Union.								2,058½			
County Street, Union to Allen.									2,654		
County Street, Allen to South.										1,202	
Cottage Street, Grove to Court.											2,078
Court Street, County to Cottage.									768		
Court Street, Cottage to Cedar.										857	
Court Street, Cedar to 89 feet W. Emerson.											687
Court Street, 89 feet W. Emerson to Tannery.						785					
Cypress Street, Maxfield to Kempton.											1,012½
Durfee Street, Mt. Pleasant to Ashland.							240				
Elm Street, County to Purchase.											1,247
Elm Street, Purchase east.						821					
Eighth Street, Union to Spring.											256
Eighth Street, Union to Elm.						740					
Emerson Street, Court north.					141						
Foster Street, Maxfield to Middle.											1,893½
Fourth Street, Union to Russell.				1,840							
Front Street, Middle to Walnut.					1,885						
Grinnell Street, Water to Prospect.											
Grove Street, Anthony to Cottage.											218½

Location of lines of Pipe.	Cast Iron Pipe.						Cement Lined Pipe.				
	16 in. Feet.	12 in. Feet.	10 in. Feet.	8 in. Feet.	6 in. Feet.	4 in. Feet.	12 in. Feet.	10 in. Feet.	8 in. Feet.	6 in. Feet.	4 in. Feet.
Hall's Court.						195					
Hawthorne Street, County west.						250					
Hawthorne Street, Orchard to Cottage.											471¾
Hazard Street, County to Purchase.						950					
High Street, Purchase east.						829					
Hillman Street, County to Purchase.									1,229		
Kempton Street, Cedar to Cypress.					365						
Kempton Street, Cypress to County.										822½	
Kempton Street, County to Foster.											749
Kempton Street, Foster to Purchase.						455					
Maxfield Street, County to Cypress.									787½		
Branch pipes to Hydrants.					43	330				122	523
Maxfield Street, Foster to State.											209¼
Maxfield Street, Foster to Ray.						720					
Maple Place, Union south.						195					
Morgan Street, County west.						250					
Middle Street, Cedar east.						520					
Middle Street, County to Water.										2,061½	
Middle Street, Water to Front.					280						
Mt. Pleasant Street, Distributing Reservoir to Durfee.							1,626				
North Street, County to Purchase.											1,211
Orchard Street, Bush to Hawthorne.											826½
Pearl Street, Purchase to Ray.						285					
Peckham Street, Engine-House to Distributing Reservoir.	2,207	28									
Purchase Street, Engine-House to Pearl.			4,096								
Purchase Street, Pearl to Union.								3,663			
Pleasant Street, North to Hillman.						300					
Prospect Street, Grinnell to Glass Works.						415					
Robeson Street, County to Ashland.							375				
Rodman Street, Water to Thayer & Judd's Parafine Works.						355					
Ray Street, Maxfield to Wamsutta.					2,845						
Ray Street, Wamsutta North.				617							
Russell Street, Fourth to Sixth.						480					
School Street, Sixth to Seventh.											249½
Second Street, Cannon to William.						2,210					
Seventh Street. Spring to Walnut.											645
Sixth Street. Middle to Bedford.											3,170
Spring Street. Eighth to Seventh.											255¼
State Street, Maxfield to Willis.											1,026¼
Sycamore Street, Walden to County.						375					

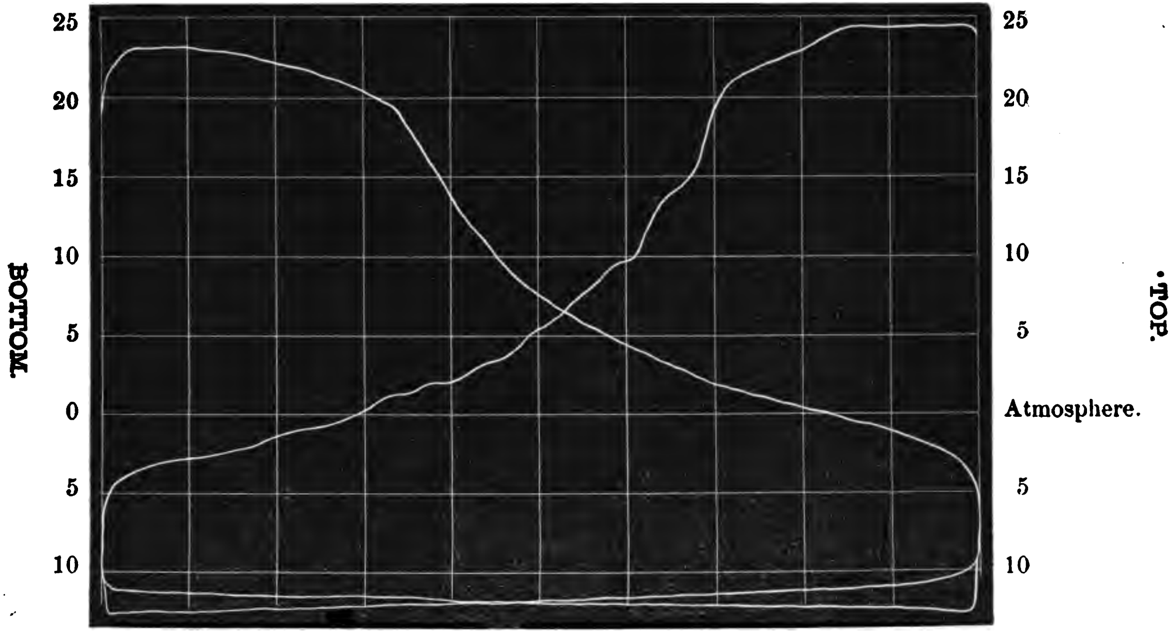
Location of lines of Pipe.	Cast Iron Pipe.						Cement Lined Pipe.				
	16 in. Feet.	12 in. Feet.	10 in. Feet.	8 in. Feet.	6 in. Feet.	4 in. Feet.	12 in. Feet.	10 in. Feet.	8 in. Feet.	6 in. Feet.	4 in. Feet.
Sycamore Street, Summer to Chestnut.						231					
South Street, County to Water.										1,099¼	
Steamboat Wharf, Front east.						145					
Third Street, Union to Bedford.											2,170¼
Thomas Street, Sycamore to Hillman.						615					
Union Street, County west.						290					
Union Street, Cottage to Maple Place.						260					
Union Street, County to Water.									2,105¼		
Washington Street, County to Bonney.											946¾
Walnut Street, County to Third.										1,268	
Walnut Street, Third to Front.					900						
Walnut Street, Sycamore to Hillman.						615					
Wamsutta Street, Purchase east.				1,056							
William Street, County to Purchase.											1,258½
William Street, Purchase to Water.						885					
Willis Street, County to State.										338	
Willis Street, Purchase to Ray.					280						
Water Street, Hillman to South.					5,671½						
Branch pipes to manufactories in Streets.				35	165	87					
Pipes in manufactories.						682					
	2,207	28	4,096	3.548	13,865½	17,230	6.179	5.721¾	7,543½	9,511¼	22,233¾

Cast Iron Pipe, - - - - - - - - - - - - - - - - - -	40,974½
Cement Lined Pipe, - - - - - - - - - - - - - - - - -	51,189½
Whole number of feet, - - - - - - - - - - - - - - - -	92,164

Or seventeen and forty-five one hundredths miles.

Fig. I.

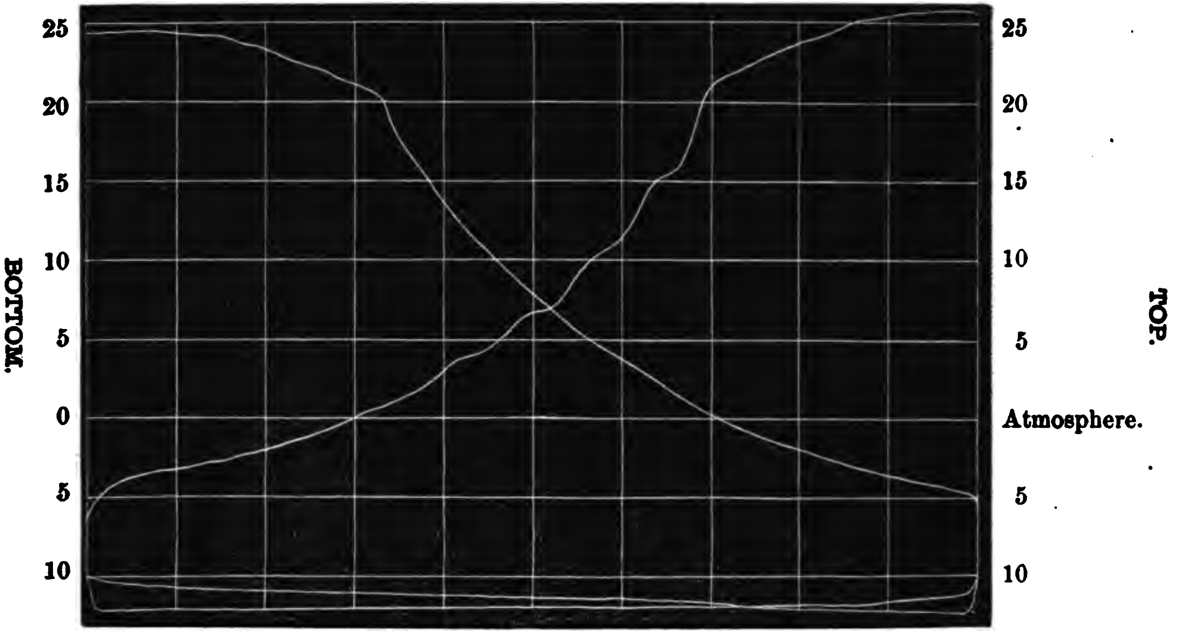
Diagram taken from Steam Cylinder, Dec. 9, 1869, 9 h. 40 m. A. M.



Steam 27 lbs. Vacuum 26 in. No. of revolutions per minute 12.9.

Fig II.

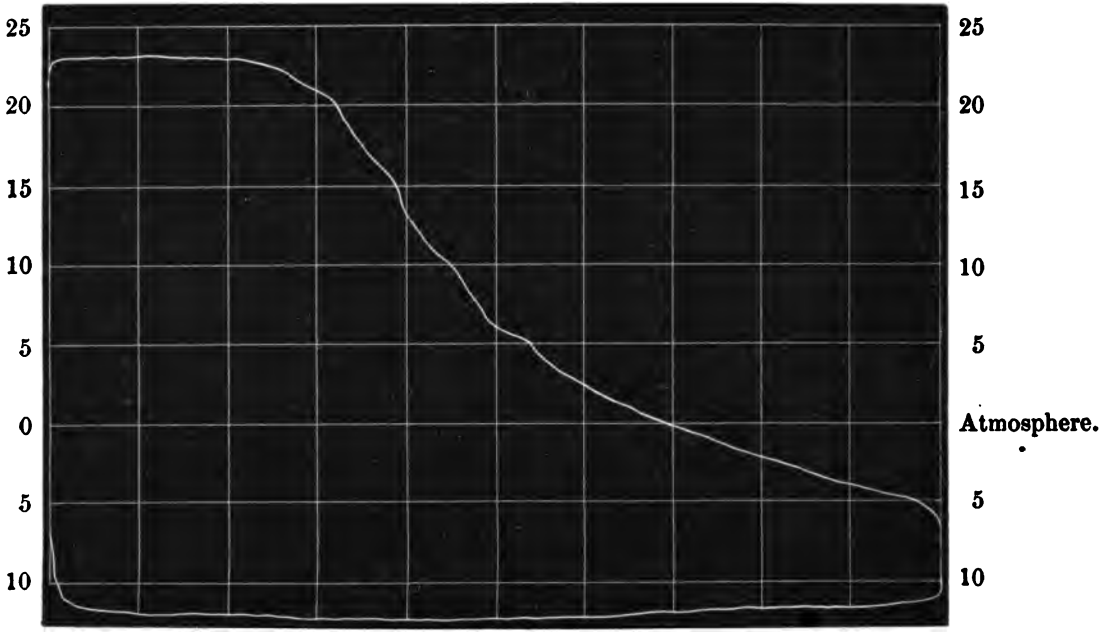
Diagram taken from Steam Cylinder, Dec. 9, 1869, 12 h. 24 m. P. M.



Steam 26 lbs. Vacuum 26 in. No. of revolutions per minute 13.

Fig. III.

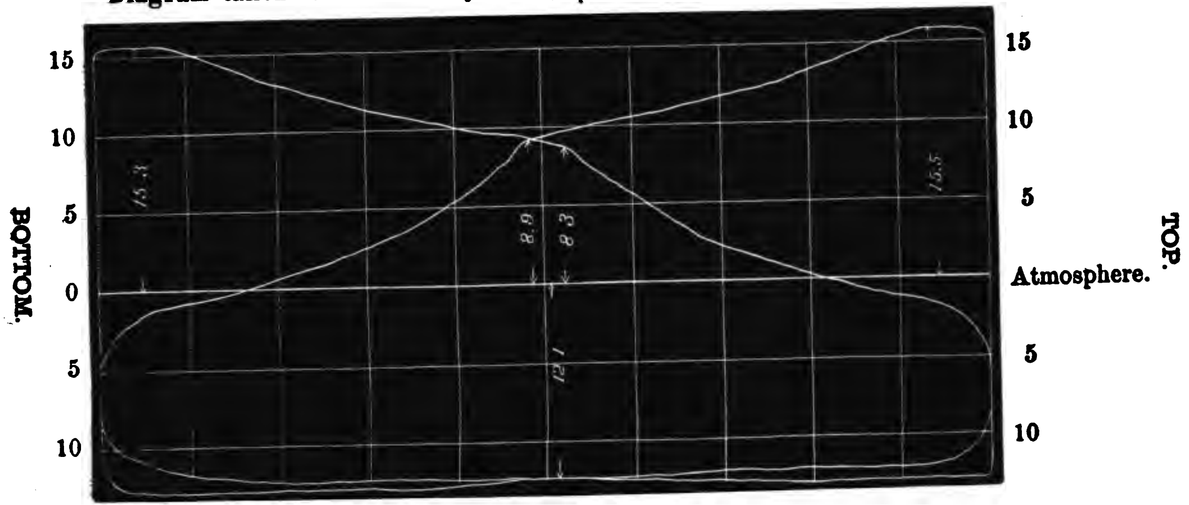
Diagram taken from lower end of Steam Cylinder, Dec. 9, 1869, 12 h. 15 m. P. M.



Steam 25.5 lbs. Vacuum 26 in. No. of revolutions per minute 12.3.

Fig. IV.

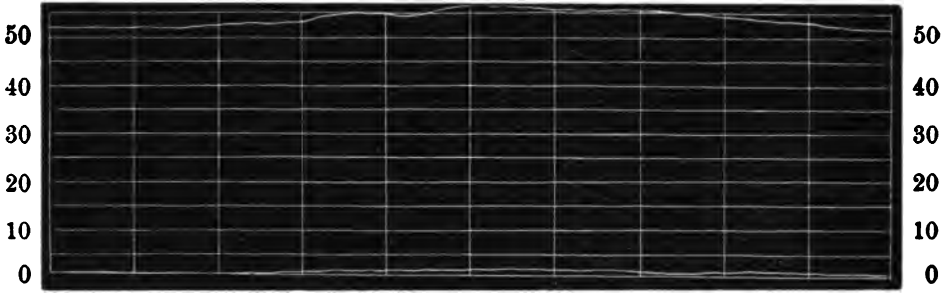
Diagram taken from Steam Cylinder, Dec. 14, 1869, 10 h. 30 m. A. M.



Steam 16 lbs. Vacuum 26.25 in. No. of revolutions per minute 10.6.

Fig. V.

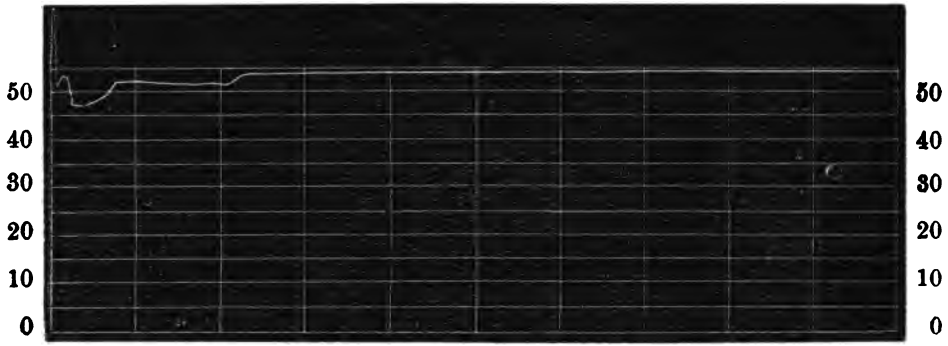
Diagram taken from West Pump, (up-stroke,) Dec. 9, 1869, 1 h. 55 m. P. M.



The suction is not indicated on this diagram. No. of revolutions per minute 13.1.

Fig. VI.

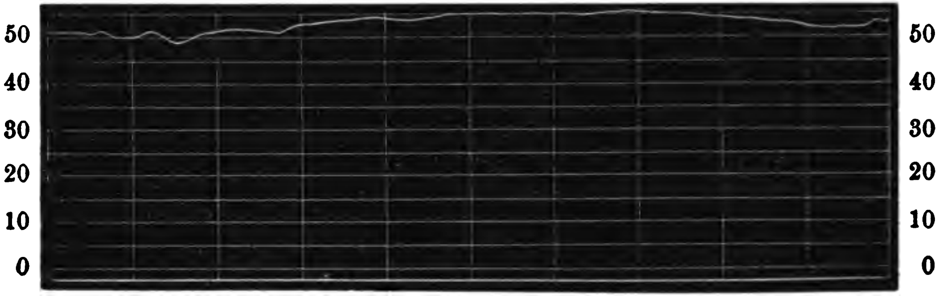
Diagram taken from West Pump, (down-stroke,) Dec. 9, 1869, 1 h. 57 m. P. M.



No. of revolutions per minute 13.1.

Fig. VII.

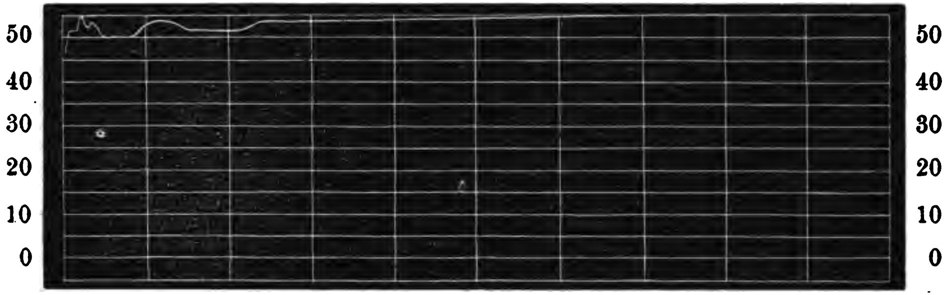
Diagram taken from West Pump, (up-stroke,) similar to Fig. V, Dec. 9, 1869, 1 h. 59 m. P. M.



No. of revolutions per minute 13.1.

Fig. VIII.

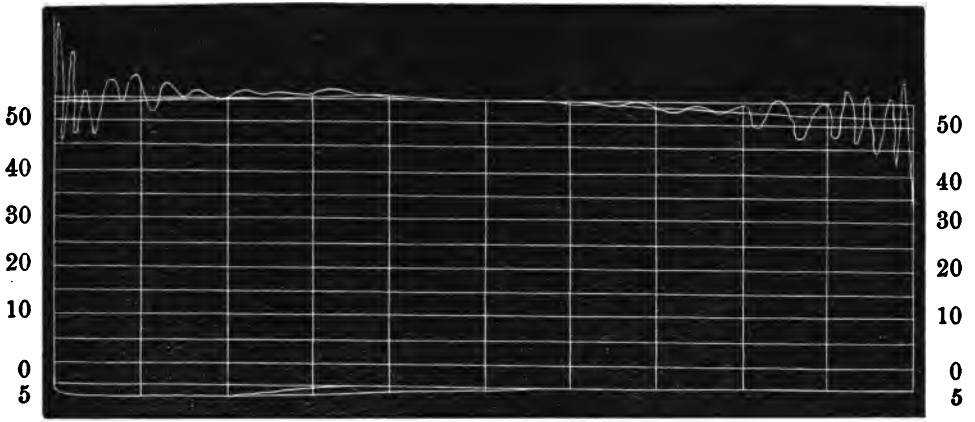
Diagram taken from West Pump, (down-stroke,) similar to Fig. VI, Dec. 9, 1869, 2 h. 0 m. P. M.



No. of revolutions per minute 13.1.

Fig. IX.

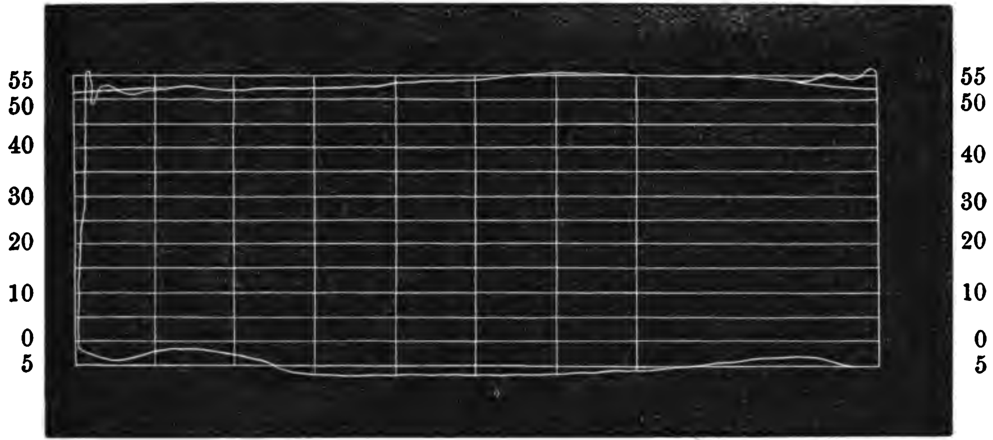
Diagram taken from East Pump, (up and down-strokes,) Dec. 10, 1869, 12 h. 25 m. P. M.



The lower line, below the atmospheric line, indicates the suction. No. of revolutions per minute 12.9.

Fig. X.

Diagram taken from West Pump, (up and down-strokes,) Dec. 10, 1869, 1 h. 5 m. P. M.



The lower line, below the atmospheric line, shows the suction. No. of revolutions per minute 12.6.

S.

REMARKS.
closed and up-take door open. by having too much grate surface.
face reduced 13 per cent. by piling fire brick at the back end. door opened and closed at short intervals until 1 20 P. M. was definitely closed. Dampers closed from beginning.
face again reduced 13 per cent. by piling fire brick at the back Total reduction 20 per cent. of original surface. Dampers from beginning.
on December 11th, 1869.

CENT. OF REFUSE.		Cut off.	DUTY.	
Clinker.	Total.		Per 100 pounds of coal burned.	Per 100 pounds of combustible.
5.00	16.52	0.33	46319356	56504764
5.23	20.23	About $\frac{1}{3}$	56294788	68674220
4.63	18.05	0.3145	59074333	72092233
4.95	18.26	0.54	59336497	72372322

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